The FOUNDRY

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Castings Aid in Defense of America's Cup

WHEN Skipper Vanderbilt brought the ENTERPRISE across the finish line in the fourth heat of America's Cup races of 1930, sweeping the series, 4 to 0, he demonstrated clearly the efficiency of mechanical equipment for sail control. The defender of the cup perhaps was the most daring attempt ever made to mechanize

The ENTERPRISE *Under Full Sail During One of Her Trial Runs*

a sailing boat, new materials being substituted for those long considered standard. The mast was duralumin, winches were provided for every sail, special devices were used for measuring the strain on the sail, and castings were used in many new places in the construction of the vessel. Many changes in design and materials have taken place since the running of the historic race off Cowes, Isle of Wight in 1851, when the AMERICA, a wooden boat, first won the international cup. The ENTERPRISE, this year's successful defender, is owned by the Vanderbilt syndicate and was built by the Herreshoff Mfg. Co. It has an overall length of 120 feet 9 inches, a 21-foot 10-inch beam, a sail area of 7583 square feet and a displacement of 128 tons. Castings play an important part in racing yachts, where the strength of any part may provide the difference between success or failure in important competition. Practically all of the deck fixtures on the ENTERPRISE are 18 per cent chromium stainless steel castings.

Find Where Castings Can Be Sold

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Southern Foundry

By PAT DWYER

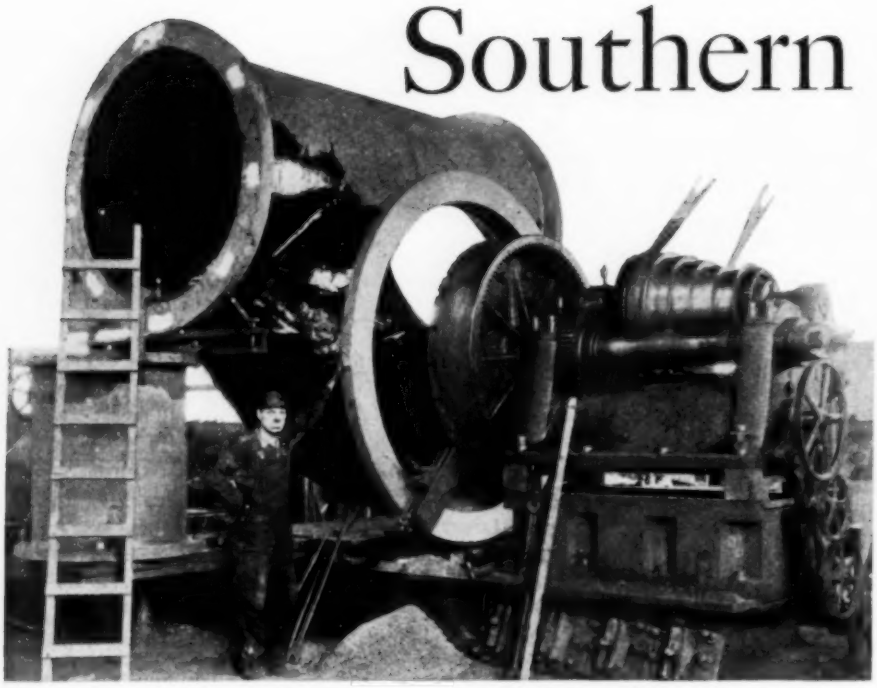


Fig. 1—The Mold for This 25,000 Pound Casting Was Made on End with the Branch on One Side of the Mold

UP TO the present, this series of articles on the cast iron pipe industry in the South has been confined to a consideration of bell and spigot pressure pipe in standard lengths and made according to various methods old and new.

In one plant falling within the scope of this inquiry, the castings are formed in sand lined metal molds revolving at high speed. In two other plants the centrifugal method is employed, but the metal molds are not lined with sand. These plants also maintain departments where dry sand molds and cores are employed and where the castings are poured in a vertical position.

The most radical departure from established methods is found in a fourth plant where pipes up to 12 inches diameter and 16 feet in length are formed with green sand molds and green sand cores and where the metal is poured while the mold is in a horizontal position.

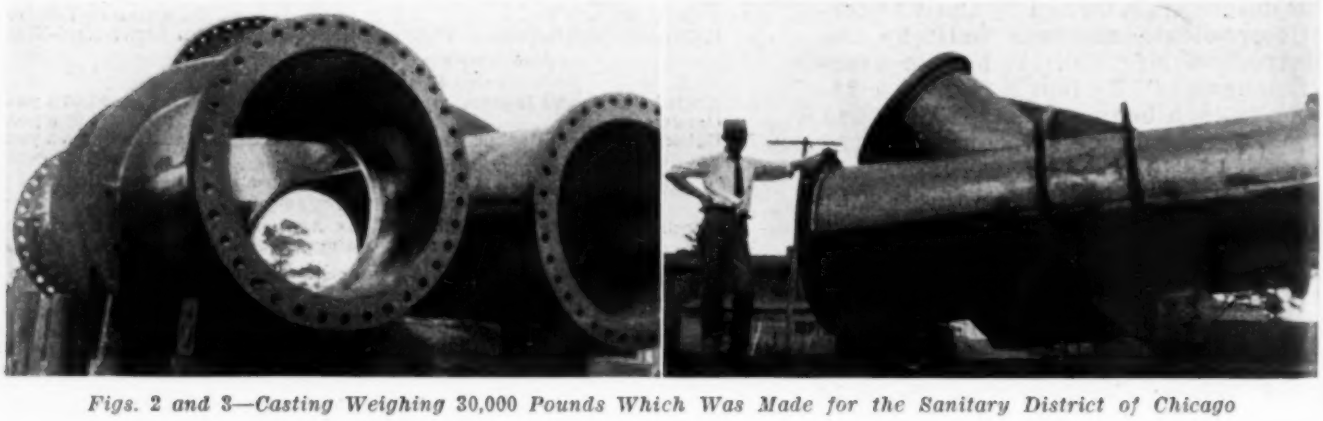
Each of these installations represent standardized methods and equipment designed for the production of vast quantities of duplicate parts. Success of the project, the ability to sell the product in a highly competitive market, is predicated on this mass production which guarantees a minimum unit cost.

Standard connections, elbows, bends, crosses and other shapes also are produced to a great extent with the aid of special equipment and on a mass production basis. Every one in any definite classification is an exact duplicate of the others.

By far the greater part of every pipe line, long or short, in fact of every industrial pipe installation, is made up of standard straight lengths. Standard fittings and connections serve to regulate, divert, transfer or check the flow of material wherever necessary.

However, occasions constantly arise where a special section of pipe is required and this constitutes one of the comparatively few jobs which still depend on manual skill and dexterity and a large measure of resourcefulness on the part of the foundryman. This is particularly true on large pipe sections, of peculiar and intricate design. Usually only one casting is ordered and therefore the foundryman has no opportunity to try a few practice swings. The casting must be a success the first time if it is to yield any profit.

Extensive mechanical equipment especially designed for the purpose costs comparatively



Figs. 2 and 3—Casting Weighing 30,000 Pounds Which Was Made for the Sanitary District of Chicago

CONCENTRATES On *Special Pipe Shapes*

nothing when the cost is distributed over thousands of castings. The cost usually is prohibitive when considered in connection with the production of a single casting. The cost item usually is the determining factor in the style of pattern and flask, also in deciding whether the mold and core shall be formed in green sand, dry sand or loam, or, in any of the several possible combinations of these materials.

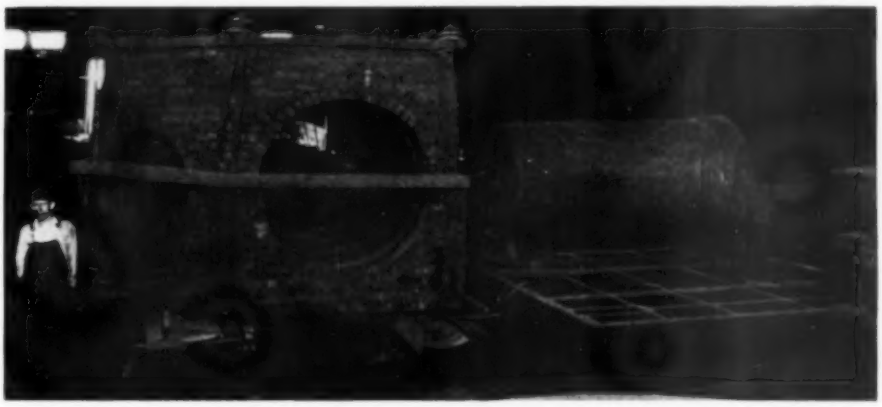


Fig. 6—The Mold Was Built of Bricks and Loam and the Core Was Formed on a Built Up Arbor. Mold and Core Were Dried

During the 30-year period of its existence the Bessemer Foundry & Machine Co., Bessemer, Ala., has specialized—if a foundry can be said to specialize under these conditions—in the production of a wide line of miscellaneous castings in which odd, peculiar, intricate and large pipe connections occupied a prominent place.

In 1889, the late Louis Hoster went to Bessemer as secretary and manager of a new foundry erected there by Howard & Harrison of St. Louis. This was the first pipe foundry established in Alabama and was operated under the management of Mr. Hoster for the original owners until 1900 when it was absorbed by the United States Pipe & Foundry Co.

With the passing of the Howard & Harrison plant into the hands of its new owners, Louis Hoster retired to establish the Bessemer Foundry & Machine Co., a general jobbing foundry designed to meet some of the demands of a rapidly growing industrial community. Since his death, the business has been conducted by his son, the present Louis Hoster, president of the company. The remarkable growth and expansion of Birmingham and the Birmingham district during the past 30 years has been touched upon in the introductory number of the present series. For all present purposes it is sufficient to say that the Bessemer Foundry & Machine Co. participated to the full in the industrial development and contributed an appreciable quota of castings to the installation of every great plant in the district. In recent years castings have been supplied for various types of installations in practically every large city in the country.

Some of the jobs were and are of a repetition character, but the great majority were and are in the one-off class where patterns, flasks and methods had to be adapted in a special manner to meet individual requirements. Several typical castings of this kind are shown in the accompanying illustrations.

For example there is a 66 x 66 x 96-inch offset bullhead *T* fitting shown in Fig. 1. This casting

Fig. 4—Shipment of Flanged Suction Fittings Each Weighing 15,000 Pounds. Fig. 5—Each Tee Weighs 19,000 Pounds

Fig. 7—Mold and Core for This 11,000-Pound Casting Were Swept at the Same Time

was made for the water circulation system of the Kansas City Power & Light Co., and weighed 25,000 pounds. This mold was made on end with the branch at one side. Fig. 1 also shows how the tools in the machine shop are adapted to cope with jobs outside their normal capacity. The casting was anchored firmly in place and a tool attached to the face plate served to face the flange on the casting.

Another casting worthy of attention is the 42-inch 5-way junction pipe fitting shown in Figs. 2 and 3. This casting weighed 30,000 pounds and was made for the sanitary district of Chicago. A shipment of flanged suction fittings for the same locality, 108 inches diameter and weighing 15,000 pounds each, is shown in Fig. 4. Part of another shipment for the same customer is shown in Fig. 5. Each of the three 48 x 54 x 54-inch bell and spigot *Tees* on the nearest flat car, weighs 19,000 pounds. It is also interesting to note that these castings were molded on end, with the bell end on the bottom.

A typical mold and core for a 48-inch bell and spigot connection with a 24-inch branch are shown in Fig. 6. The mold was built of bricks and loam and the core was formed in sand on a built up cast iron arbor. Mold and core were built simultaneously, with the core inside the mold. Later they were separated so that the faces might be slicked and blacked. Also that they might be dried more readily. Not the least of the many advantages of making a mold in this manner is the certainty that the core will fit accurately in place and thus insure a uniform thickness of metal in the casting.

Reduce the Cost

One of these molds requires a little more time in the foundry than one in which a complete pattern, corebox and flask are supplied, but the net cost of the job is the least of any method that may be employed. Also the method practically is a guarantee that the casting will be perfect, clean and free from all defects and accurate in shape and in every dimension.

The only equipment required for this mold was a skeleton pattern and a few sweeps, supplemented by a foundation plate, a top plate and lifting plate for the mold and an arbor for the core. The hook bolts, washers, standards, curbing and other accessories, form part of the regular shop equipment and are available for any job. Even the core arbor may be taken apart and reassembled to suit several other pipe shapes.

In building this mold the foundation plate was placed level on suitable blocks and the bottom half of the pipe pattern was adjusted in place so that the parting line, or joint line of the pattern also was level. The brick work then was built up from the plate until it almost reached the joint line of the pattern. A coat of loam was applied to the top and struck off flush with the edge of the pattern all around. A thickness of loam also was applied to the brick face surrounding the pattern and this thickness was finished to shape by suitable strikes operated between the ribs of which the pattern was composed. One strike extended beyond the ends and formed suitable core prints. An iron block was built in the wall under each print to support the weight of the core.

Molding sand then was packed between the ribs of the pattern to correspond to the thickness of metal in the proposed casting. The sand was slicked and covered with sheets of paper and then the mold became a corebox. The core arbor was made up of a main backbone, a branch backbone, a circular end plate for the end of each print and a number of semi-

Fig. 8—Thin Trough Castings for a Filtration Project Were Molded in Green Sand on a Production Basis in Special Cast Iron Flasks

circular wings or bars spaced 6 inches apart after the manner of bars in a cope. Each of the auxiliary parts was provided with an opening by which it was slipped over the back bone. Once in place it was held there by one or two wedges. Additional holes in the end plates served as vent holes for the escape of gas during the pouring period.

After the core arbor was adjusted in place with the lower edge of each end plate resting on the iron block in the mold print, it was rammed full of sand up to the joint of the pattern. Then the upper half of the skeleton pattern was matched on the lower half and the upper half of the core was rammed. In this instance the item of supplying the metal thickness was reversed. Instead of forming the shape of the core on the inside of the skeleton pattern and then building the necessary thickness of sand afterward, the sand was packed to the outside of the skeleton pattern and slicked off to form the counterpart of a solid pattern. The core prints of course were finished to the proper size. The entire surface then was covered with sheets of paper and the lifting plate, shown at the center of the mold in Fig. 6 was adjusted in place.

A row of *headers*, whole bricks laid on edge, was built over each print and the remainder of the wall was built up until on the level it was about 12 inches above the highest point on the pattern. A thickness of loam was spread over the pattern all the way around and the bricks were laid against it in the usual manner.

Fig. 10—Offset Trunnions on the Drag Facilitated the Rolling Process

A cover plate with suitable openings for the gate and risers was bedded in a thickness of mud on top of the brick work. Standards were erected from the lifting plate to the covering plate and then the two plates were anchored to each other by a number of hook bolts as shown in the illustration. The cope then was removed and placed on horses so that the molder could go inside and finish the face and black it.

Short strikes with shoulders corresponding to the thickness of metal were employed to remove the surplus sand from the core after which the upper part of the pattern was removed. The core was lifted out and placed upon supports on the core oven car where minor repairs were effected and where the surface was blackwashed. The device shown at the end of the core in Fig. 6, was attached to the end of the arbor and to the bottom of the car to prevent the core from wabbling while the car was in motion.

This device is a 1-inch square steel bar with a toe at the lower end to engage the bottom edge of the car. A link is slipped down over it until it comes to rest on the end of the arbor. Then a wedge is driven between the link and the bar and serves as an effectual anchor. A light tap of a hammer releases the link when the time comes to remove the core from the car on which it has been dried.

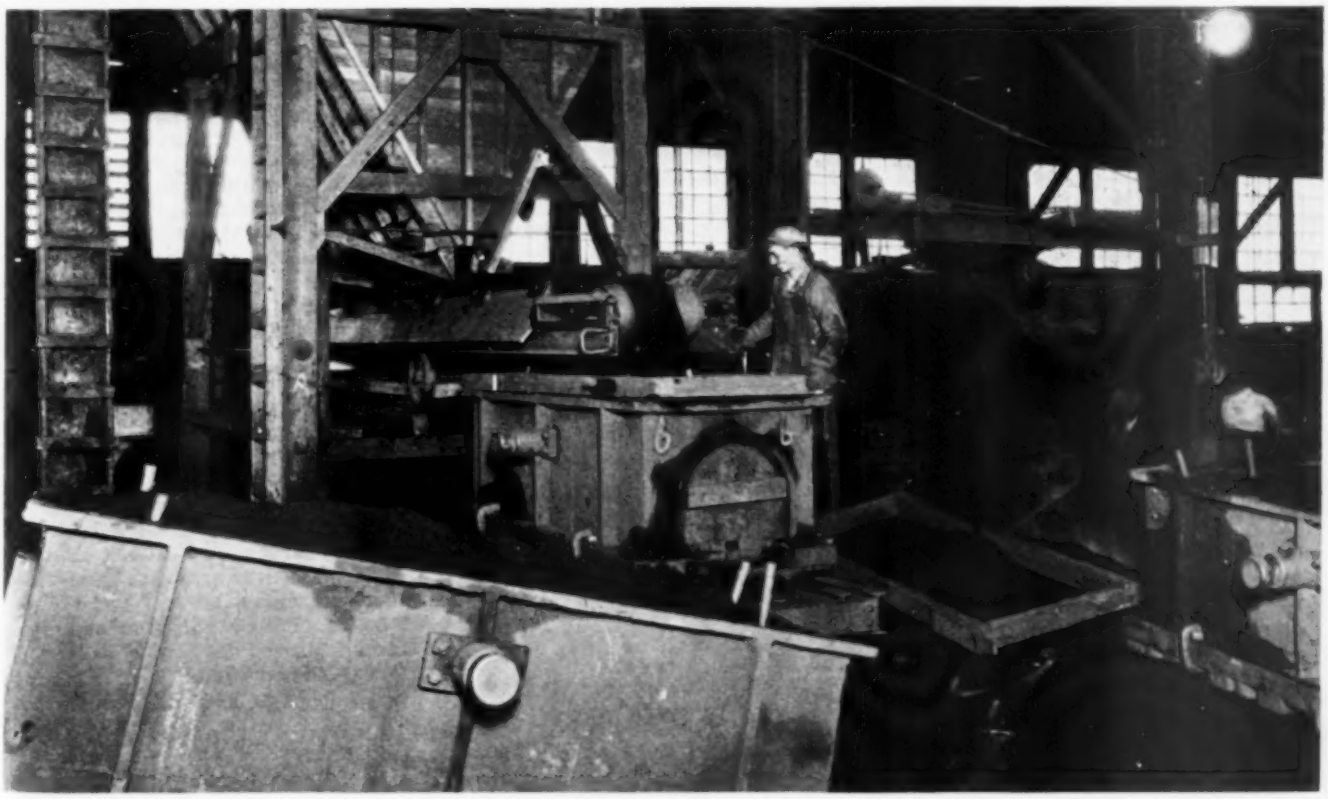


Fig. 9—The Company Designed and Erected a Sand Preparation and Flask Filling Device for Use in Connection with the Trough Castings

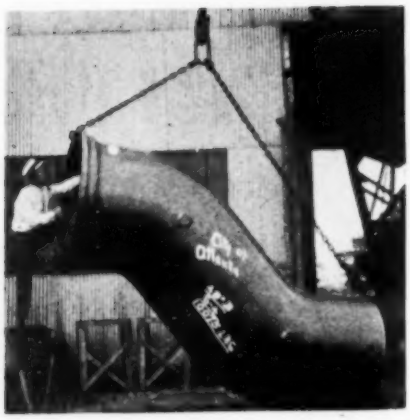


Fig. 11—Various Dimensions of Pipe Are Held to Close Limits

After the bottom part of the mold was finished and blacked it was lifted on to the car and the upper half of the mold was placed on top of it. Then mold and core were placed in the oven until they were thoroughly dried. Afterward they were removed, placed in a pit in the floor and the mold was assembled in the usual manner. Iron standards were erected on the ends of the core arbor and wedged at the upper ends under projections on the cover plate. Suitable slings engaging opposite projections on the top and bottom plates were employed to bind the mold firmly together. Sometimes a plain templet laid on the joint takes the place of the skeleton pattern. The method of building the mold is substantially the same.

Sweep the Mold

A modification of the foregoing method was employed to form the mold for the acid egg or retort shown in Fig. 7, with a 2-foot opening in the top, a 3-inch opening in the bottom and weighing 11,000 pounds. A spindle and a few sweeps constituted the only pattern equipment required on this job.

A loam mold was built as high as the parting line and swept on the inside to the shape of the casting. A thickness of sand was swept against the face to correspond to the thickness of metal. A half spherical arbor with suitable staples on top was lowered into the mold and rammed with sand up to the parting line. Three long hook bolts attached to the staples were erected, also three standards. The remainder of the core, with a large coke bed in the center, was built up and swept to the desired shape and size of the casting.

Close the Mold

A lifting ring was adjusted on the joint and the outside of the mold was built in brick and loam up to a point where it was struck off flush with the upper face of the flange. The mold then was taken apart, finished and dried.

In assembling the mold the core was lowered into place until it came to rest on wood slabs, the thickness of the metal, in the proposed casting. The 3-inch print in the center of the bottom located the core accurately in a vertical position. The upper part of the mold then was lowered into place and a slab core was placed over the flange. The standards from the core arbor were wedged under projections on the cover plate and the bolts were pulled up tight. The cope with the core suspended, was lifted off temporarily for general examination of the mold and for removal of the thickness slabs in the bottom. Then it was replaced and the mold was made ready for receipt of the metal.

Where an order for castings runs into several hundreds or thousands, special equipment is provided. Several stages in the production of a great number of duplicate castings for a Detroit filtration plant are shown in the accompanying illustrations Figs. 8, 9, 10 and 12. Incidentally the castings were faced on both ends, drilled and assembled in 42-foot lengths and then subjected to a water test for leakage before they were disassembled and stacked as in Fig. 12 for shipment. The ingenious setup in the machine shop for handling this job deserves a chapter for itself, and besides it is outside the scope of the present description dealing only with the foundry features.

A set of special flasks was made for these castings with the trunnions set as nearly as possible on the center of gravity line to facilitate rolling them over. Offset trunnions were placed on the drags on account of the high mound of sand above the parting line. The ends of the drags were built up to correspond with the shape of the casting and the drags were rolled over endways instead of in the usual manner so that the ends of the flasks might support the body of sand during the rolling process. The copes also were rolled in a similar manner so that the sides of the flask might support the sand. An open work grid was attached to the bottom of the drag instead of the usual bottom plate.

The green sand in this foundry is comparatively coarse and open and requires little or no venting with a wire. In this instance the drag was vented by inserting three long rods through holes in the end plate before the drag was filled with sand. These rods were pulled out before the pattern was removed from the mold.

Use Two Patterns

Two patterns were employed, one for the cope and one for the drag. They were built up solidly and substantially and the flasks were machined and fitted accurately to fit the patterns and each other. Long detachable pins were employed to guide the cope on to the drag and then were removed to serve in like manner on each flask in turn.

The metal was poured in a pouring basin at each end which opened into two 1-inch upright runners. The lower ends of the runners discharged the metal into a shallow channel which followed the curve of the mold almost to the bottom on both sides. Metal from this continuous channel entered the mold through a number of shallow, flat gates spaced about 2 inches apart. A special piece of sand handling equipment built by the local staff is shown in Fig. 9. From the shakeout station the sand is elevated and discharged into a hopper. From the hopper it falls on to a moving belt mounted on a carriage. The operator moves the carriage back and forth at will and thus fills all parts of the flask, which then is rammed on a jolt machine, made by the Tabor Mfg. Co., Philadelphia. A loose wood frame placed on top of the flask holds the surplus sand required to compensate for the reduction in bulk after it has been jolted down.

Fig. 12—Trough Castings Were Assembled and Tested Before They Were Stacked for Shipment

This is the ninth of a series of articles dealing with the cast iron pipe industry in the South. Succeeding articles are scheduled for publication in early future issues of THE FOUNDRY. THE EDITORS.

Casting Sale Price Determined by Foundry Costs

By Edwin Bremer

DURING the past few years considerable stress has been placed upon the value of some type of cost sytem for every foundry whether large or small. In the small foundry the cost system can be reduced to its simplest form and applied practically without added cost. In large foundries the system is used in its more elaborate and detailed form to supply accurate information on every foundry operation to the executives and department heads.

Produce Variety of Castings

After the cost system is established and figures are available, the next step is to apply the knowledge gained to the selling of the castings so that a reasonable profit is obtained on every casting sold. Since all foundrymen are interested intensely in the latter phase, a description of the methods used in a prominent nonferrous jobbing foundry will enable them to compare it to the system they have or to adapt it to their own particular needs.

Several years ago the American Mfg. Co., Dayton, O., produced finished water filters and fire fighting equipment. The departments included a brass foundry, machining department and a plating division. Later, the firm turned to the jobbing field and for the past several years has been a contract plant. The foundry department which was described in the July 15 issue has an average capacity of 1,000,000 pounds of brass, bronze and aluminum alloy castings which range from one ounce to 1000 pounds in weight. Castings are supplied in a sandblasted, polished or plated finish as the customer desires.

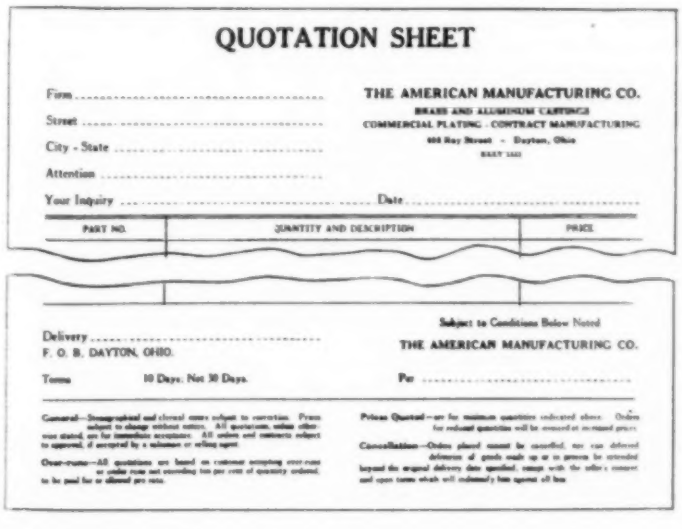
When the firm bids on an order for a lot of castings, the following procedure takes place: A blue print or sample casting is obtained from the customer with data on any existing pattern and corebox equipment. That data is turned over to the foundry superintendent. If no pattern or corebox equipment is available, the foundry superintendent decides on the best flask size and makes a layout for the proper number of castings for the flask. The layout shows the arrangement of the castings and the method of gating. He then determines from previous records and experience, the average molder's daily output of molds for the particular job in hand. He also determines the cleaning, grinding, and coremaking time in hours, and attaches the figures to the layout.

The layout then is sent to a local pattern shop where the cost of the pattern and core equipment is determined. After this is calculated, the layout with the various figures is sent to the cost department of the foundry for price calculation. The first step of the cost department is to convert the foundry superintendent's estimate into pounds of metal per man per day. His layout shows the number of pieces per mold and the number of molds per day. The weight per piece is determined by volume calculation or from a sample casting. This weight with the number in a mold and the number of molds per day per man enables the cost department to calculate the number of pounds per day per man for the particular casting involved.

Calculate Metal Required

In calculating the actual weight of metal required to pour a given casting or gate of castings, the American Mfg. Co., allows one-third of the total weight for gates and risers. This figure has been obtained from records of its foundry production. However, in determining the total weight of the castings, gates and risers from the weight of the castings only, one-half of this latter value must be added to give the correct total weight. For example, if the total weight of castings, gates and risers is 750 pounds, and one-third of the weight is gates and risers, the actual weight of castings is 500 pounds. Figuring conversely as is done in computations where only the weight of the castings is given, and which in the present case is 500 pounds, one-half of this value or 250 pounds must be added to give 750 pounds, the correct total weight.

Since melting, as practiced in the commercial foundry, cannot be carried out without loss, this must be included in the final weight computation. The melting loss may vary from foundry to foundry, but in the particular foundry mentioned, the yearly record shows the melting loss to be 2½ per cent. In other words, for every 100 pounds of metal put



QUOTATION SHEET

Firm .....

Street .....

City - State .....

Attention .....

Your Inquiry ..... Date .....

THE AMERICAN MANUFACTURING CO.
BRASS AND ALUMINUM CASTINGS
COMMERCIAL PLATING - CONTRACT MANUFACTURING
[illegible] Ray Street - Dayton, Ohio

PART NO.	QUANTITY AND DESCRIPTION	PRICE

Delivery .....
F. O. B. DAYTON, OHIO.

Terms 10 Days. Net 30 Days.

Subject to Conditions Below Noted
THE AMERICAN MANUFACTURING CO.

Per .....

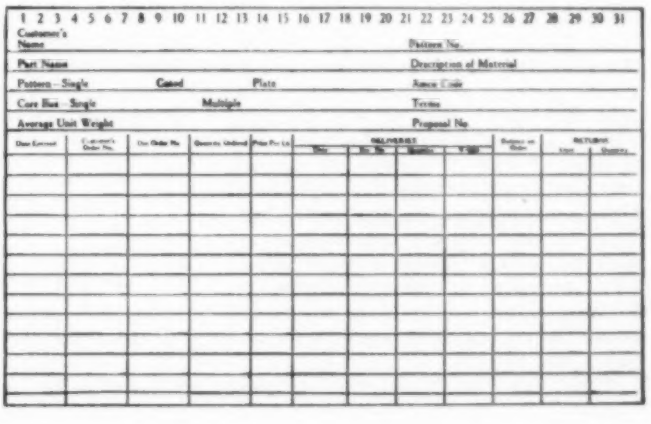
General—[illegible] subject to correction. Prices subject to change without notice. All quotations, unless otherwise stated, are for immediate acceptance. All orders and contracts subject to approval, if accepted by a salesman or selling agent.

Over-runs—All quotations are based on customer accepting over-runs or under runs not exceeding ten per cent of quantity ordered, to be paid for at ordered per rate.

Prices Quoted—are for minimum quantities indicated above. Orders for reduced quantities will be executed at increased prices.

Cancellation—Orders placed cannot be cancelled, nor can deferred deliveries of goods made up or in process be extended beyond the original delivery date specified, except with the seller's consent and upon terms which will indemnify him against all loss.

Fig. 1—(Left)—The Quotation Sheet States the Price of a Given Quantity of Castings. Fig. 2—(Below)—Information on the Status of Any Order May Be Shown on the Card



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Customer's Name ..... Pattern No. .....

Part Name ..... Description of Material .....

Pattern - Single ..... Cored ..... Plate ..... Annex Code .....

Core Box - Single ..... Multiple ..... Terms .....

Average Unit Weight ..... Proposal No. .....

Date Entered	Customer's Order No.	Our Order No.	Quantity Ordered	Price Per Lb.	DELIVERIES				Balance on Order	RETURNS	
					Date	No. Pcs.	Quantity	Wt.		Date	Quantity

into the furnace, only 97½ pounds are recovered. Therefore, the previous weight must be divided by 0.975 to obtain the actual amount of metal required. Using the value of 750 pounds, the final figure becomes 769.23 pounds or say 769¼ pounds.

Methods of calculating the melting cost may vary from foundry to foundry, and include metal costs as laid down in the foundry, labor, fuel, miscellaneous supplies, repairs and the department's share of the general overhead. In some plants these figures may be itemized separately when calculating the molten metal cost, but it has been found satisfactory by the American Mfg. Co. to lump the various items together and use only one figure

THE AMERICAN MANUFACTURING COMPANY

FOUNDRY METAL REPORT

WEEK ENDING _____ 19____

DATE	B-1 (88-10-2)		B-3 (85-5-5-5)		B-5 (80-10-10)		A-5 ALUM. REMELT		Y-1 YELLOW BRASS		M-1 MANGANESE		A-3 (92-8)		C-1 COPPER					
	INGOT	GATES	INGOT	GATES	INGOT	GATES	INGOT	GATES	INGOT	GATES	INGOT	GATES	INGOT	GATES						
MON.																				
TUES.																				
WED.																				
THUR.																				
FRI.																				
SAT.																				
TOTAL																				

SUMMARY

KIND OF METAL	INGOT	GATES	
B-1			
B-3			
B-5			
A-5			
Y-1			
M-1			
TOTAL			

Fig. 3—The Inventory Sheet Contains Columns for Both Daily and Weekly Consumption of Materials

which is that for the cost of a pound of molten metal ready to be poured.

With this figure established from records maintained over a long period of time, it is an easy matter to arrive at the cost of metal for any given weight of castings. For example using the weight previously calculated or 769¼ pounds with an assumed metal cost of 17 cents a pound at the mold, the total metal cost will be $120.7625. To this value must be added molding and cleaning costs and a fair profit.

If the molding costs were $16.00, the cleaning costs $6.00 and a fair profit, 3 cents a pound or $23.0775, then the total cost of the castings will be $165.84. However, the weight of 769¼ pounds is not all castings but includes the weight of sprues and risers, and the metal loss. The actual weight of metal recovered is 750 pounds of which only 500 pounds is salable castings. Consequently, there is a return of scrap metal of 250 pounds in the gates and risers.

Since this metal can only be considered as scrap, it has a reduced value compared to the original metal melted. Assuming that the scrap value is 14 cents a pound, then the total value of the scrap is $35. As this metal is returned to the foundry, it cannot be charged to the castings so must be subtracted from the cost previously given. Therefore, the cost of the castings becomes $165.84 minus $35 or $130.84. As this is the cost of 500 pounds of castings, the cost of one pound will be $130.84 divided by 500 or $0.2602 or in round numbers 26 cents a pound.

Some times a quotation is desired by the piece rather than by the pound. This practice is used for small parts such as automobile fittings, etc. If such is the case it is an easy matter to weigh 50 or 100 small finished castings and obtain the average weight per piece. With that weight established, the price per piece can be determined.

After the calculations have been completed and verified, the quotation is forwarded to the prospective customer on a standard form shown in Fig. 1. As will be observed, sufficient space is allowed for a complete description of the casting as well as the part number, quantity and price. Special attention is called to the conditions appended to the bottom of the quotation sheets and which are a part of the transaction. These are:

General—Stenographical and clerical errors subject to correction. Prices subject to change without notice. All quotations, unless otherwise stated, are for immediate acceptance.

All orders and contracts subject to approval, if accepted by a salesman or selling agent of the company.

Over-runs—All quotations are based on customer accepting over-runs or under-runs not exceeding ten per cent of quantity ordered, to be paid for or allowed pro rata.

Prices Quoted—are for minimum quantities indicated above. Orders for reduced quantities will be invoiced at increased prices.

Cancellation—Orders placed cannot be cancelled, nor can deferred deliveries of goods made up or in process be extended beyond the original delivery date specified except with seller's consent and upon terms which will indemnify him against all loss.

When the customer signifies his acceptance of the quotation, his order is entered on a yellow card 5 x 8 inches shown in Fig. 2. This card gives all the necessary data relating to the casting such as the type of pattern and corebox, weight and description at the top. The remainder of the card is devoted to columns relating to the quantity of castings ordered, deliveries and returns. The figures entered in the various columns show at a glance the status of any order. The numbers at the top refer to the days in the month, and an ordinary wire paper clip placed over any particular day calls the clerk's attention to the fact that the order needs attention on that day.

Work Is Checked

After the order is in production in the foundry for a length of time sufficient for the molders to become familiar with the job and strike a uniform operating speed, the work is time studied to check the figures used in calculating the original bid. If it is found that the estimates are low or high, that fact is noted and considered when the original order is completed and the customer desires a renewal.

If it is found that production is above that first estimated, the customer is given the benefit by a reduction in price per pound or piece as the case may be. If production is less than estimated, the new quotation bears a higher price based on the time study. If the customer objects—which is usually the case—the matter is taken up with him and he is informed of the reasons for the change. Sufficient information is given to him to show that the higher price is legitimate, and is backed with figures taken from the old and new calculations. In most cases the laying of the cards on the table retains the customer.

While many foundries only take a monthly inventory of their metals and alloys or even less frequently, the American Mfg. Co. finds that with a simple mimeographed form, a perpetual inventory can be maintained. This form shown in Fig. 3 contains vertical columns devoted to

the different types of alloys cast and whether available as ingot or gates. The horizontal columns are for the days of the week with a summary for the week. Each day the metal is weighed into and out of the foundry and tabulated on the sheet by the foundry clerk. Consequently, at any time the foundry superintendent can determine the quantity of metal available and place orders for new supplies.

Although considerable comment now is being heard about the encroachment of other materials such as brass forgings, extruded brasses, stampings, etc. on the nonferrous castings industry, the American Mfg. Co. has been able to reverse the process and take business into the sand casting field. For example, the firm now is engaged in making castings of articles that formerly were produced by other methods of fabrication. That has been accomplished by doing considerable experimental and educational work among the consumers of those products.

The experimental work consists in obtaining the article and calculating the machinery necessary and the work performed. Many times a great many of these operations can be eliminated by the proper pattern. For example, one object made from extruded bronze contained two counter-sunk holes, and serrations on one side. Formerly these were machine operations but they now are formed in the mold when casting.

While the elimination of those machining operations brought the casting cost down to a point where they could begin to compete with the extruded object, it was not sufficient. The next step was to lighten the casting by metal removal which would still leave the casting with a good margin of safety, strong enough for the service intended.

The process of lightening could not be done without the prospective customer's consent and therefore he was consulted. That of course, constitutes part of the educational work with suggestions on how by slight changes the object could be molded more easily. Usually, the person consulted is glad to have the suggestions and permit their use. Consequently, with the consent to lighten certain portions and make other slight changes, the price of the object in the cast form is less than that for the extruded piece—and the firm has another customer.

The firm also is engaged in educational work with its regular customers. This campaign consists in pointing out how if certain changes were made in the patterns, the customer could obtain prices due to lower molding costs. This plan has worked successfully, and many of the customers request the assistance of the firm when they contemplate a change in design or desired a new type of casting to fit their needs.

British Institute of Metals Meets

APPLICATION of aluminum alloys and magnesium alloys and the development of rustless iron and nickel alloys in aircraft production were discussed in a paper entitled "The Use of Nonferrous Metals in the Aeronautical Industry," which was presented as the ninth autumn lecture before the meeting of the British Institute of Metals held in Southampton, Sept. 10 and 11. The paper was presented by Prof. D. Hanson, vice president of the institute.

The general meeting of members was held in the Chantry Hall on Wednesday, Sept. 10, and a civic welcome was given by the Mayor of Southampton, Councillor Hector Young. Following the formal opening of the meeting, a number of papers were presented. In the afternoon visits were paid to the Portsmouth dockyard, the Supermarine Aviation Works at Hythe and Woolston, and the Ordnance survey office at Southampton. A reception and dance in the Royal Pier Pavillion, was held in the evening, by kind invitation of the Mayor and the Corporation of Southampton.

The Thursday morning session was devoted to the presentation of papers, and in the afternoon the members were taken to inspect the Cunard steamship MAURETANIA, while others visited the International Cold Storage & Ice Co., Ltd., the floating dock, Harland & Wolff, Ltd., and John I. Thornycroft & Co., Ltd. During the meeting ladies and members who wished to take advantage of the trip were also conducted to Romsey Abbey and Winchester, and the whole of Friday was devoted to two excursions, one to the New Forest and the other to the Isle of Wight.

Several papers of interest to the foundry industry were presented in abstract at the Wednesday session, including the following: "Gas Removal and Grain Refinement of Aluminum Alloys," by Dr. W. Rosenhain, J. D. Grogan and T. H. Schofield, National Physical laboratory, Teddington and "Pressure Die-Cast Aluminum Alloy Test-Pieces," by J. D. Grogan, National Physical laboratory, Teddington. In the latter paper the author gives the results of tests of pressure die-cast tensile test-pieces as indicating that, if certain serious technical difficulties can be overcome, the pressure casting process will yield products of excellent mechanical properties.

Discuss Aluminum Diffusion

This paper was followed by a contribution by N. W. Ageew, of the Polytechnical Institute, Leningrad, and Olga I. Vher, of the Institute of Metals, Leningrad, on "The Diffusion of Aluminum Into Iron." A contribution on "Lattice Distortion as a Factor in the Hardening of Metals" was presented by Wm. L. Fink and Kent R. Van Horn, of the aluminum research laboratories, Aluminum Co. of America, Cleveland, The last paper of the first session was entitled "A study of the Relation Between Macro and Microstructure in Some Nonferrous Alloys," by Dr. Marie L. V. Gayler, of the National Physical laboratory, Teddington.

At the morning session on Thursday, Dr. W. H. J. Vernon and L. Whitby, Chemical Research laboratory, Teedington, presented the second part of a report on the open-air corrosion of copper in a paper entitled "The Mineralogical Relationships of Corrosion Products." E. Voce, of the British Nonferrous Metals Research association, Birmingham, dealt with "Silicon-Copper Alloys and Silicon-Manganese-Copper Alloys," and Dr. E. Vaders, of Hirsch, Kupfer—und Messingwerke, A. G., Finow (Mark), Germany discussed "A New Silicon-Zinc-Copper Alloy." H. C. Dews, metallurgist, Dewrance & Co., London, presented a paper on "The Effect of Phosphorus on the Strength of Admiralty Gun-Metal." In these experiments particular attention was paid to the effect of casting temperature on the alloys. It was shown that phosphorus up to approximately 0.05 per cent has little effect on the mechanical properties or structure of Admiralty gun-metal. Above 0.05 per cent phosphorus there is a reduction in the mechanical properties.

The next paper was entitled "A Note on the Constitution of the Cadmium-Zinc Alloys," by D. Stockdale, of King's college, Cambridge. This was followed by a contribution by D. A. N. Sandifer, of The University, Birmingham, on "Pendulum Hardness Tests of Commercially Pure Metals." The last paper, by F. Hargreaves, dealt with "Heat-Treatment, Ball-Hardness, and Allotropy of Lead."

National Engineering Co. Acquires Standard

Standard Sand & Machine Co. has moved its offices from 5151 St. Clair avenue, Cleveland, to 549 West Washington boulevard, Chicago. The company recently was acquired by the National Engineering Co. and will be operated as a subsidiary but as a separate organization.

Correlation of Mechanical Tests

Involves Many Difficulties

By J. G. Pearce

Part I

THE founder, the chemist, the physicist, the metallurgist and the engineer do not agree at present on what property or quality of cast iron forms the best basis for consideration of its physical properties. The chemist favors analysis, the ultimate composition of the metal being incontrovertible. That test gives valuable information which can be obtained in no other way. However, commercial analysis usually does not include elements other than carbon, silicon, manganese, phosphorus, and sulphur, the so-called rare elements, gases, etc., being omitted. Thus a tendency arises to ascribe anomalies of behavior to these undetermined elements, or to criticize undeservedly the chemist's work because conventional analysis does not explain these irregularities. Chemical analysis does not indicate the manner in which the elements of composition are combined.

The physicist can associate changes of quality with changes in density, in thermal, electrical or magnetic properties, but the correlations are not sufficiently well known to enable these properties to be used in specifications.

The metallurgist knows that strength properties are determined primarily by structure, which is not wholly determined by composition, or even by composition and rate of cooling. Structure is the resultant of all the forces at work. Therefore he leans toward microscopic examination. The microscope gives important information not only about general structure but also about its variation from point to point in the section. It shows the distribution of compounds as they exist, but apart from the inability of the microscope to show directly the elements in solution, it is impracticable as a routine acceptance test because any given examination is localized highly and the technique of polishing and etching is not known generally.

The founder looks to some form of fracture test, preferably of a type which will yield a result before the casting actually is made, such as a chill test. The hitherto unresolved connection between composition and structure suggests that analysis always should be accompanied by some form of fracture test, microscopic or macroscopic.

The fracture test is sound for the same reason that the micro-examination is sound; but it is far less sensitive. It is logical because metal for many castings, which it would be impossible to judge by a purely mechanical test, can be judged satisfactorily by a combined fracture and chill test. Keep's test, which incorporates a chill test, is used still in some British foundries.

So much depends on the size of the casting and its purpose and composition, that a standard chill test is impracticable. Furthermore, there is no agreement on suitable form, quite apart from size. Most foundries using the test, work out a chill test empirically to suit their range of work. This duly integrates all the factors at work. It is in this sum that the foundryman really is interested.

The practical founder is aware of unexpected and unpredictable variations in the behavior of cast irons of the same composition. This has recently been confirmed in an interest-

Influencing Factors

VARIOUS authorities in many parts of the world have attempted to correlate the values of physical tests for gray iron. A wide diversity of opinion has resulted because of the variation in the many factors governing the production of gray iron. In this the first of two articles abstracted from a paper presented on behalf of the Institute of British Foundrymen at the Cleveland convention of the American Foundrymens' Association, the author explains some of the reasons for the variations. One of the greatest influences is local conditions. Others include raw materials, alloys, melting practice, mixtures and many others. The value of various machining methods for test bars also is discussed and an explanation of the graphitization of gray irons is included. The author is director and secretary, British Cast Iron Research association, Birmingham, England.

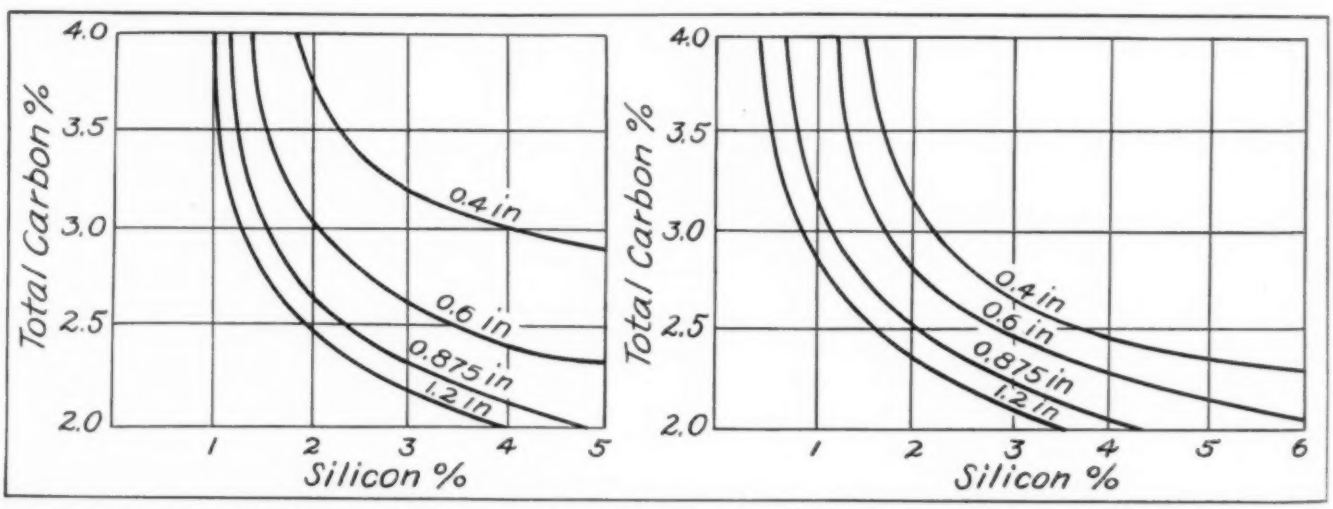


Fig. 1—Lines Separating Gray from White and Mottled Irons Crystalizing in the Ferrite-Fine Graphite System in Sand Cast Bars As Given. Fig. 2—Same for Irons of the Ferrite-Normal Graphite System

ing manner in some work done by the British Cast Iron Research association, and described by A. L. Norbury, *Journal*, Iron and Steel institute, Great Britain, Vol. 119, I, 1929.

Figs. 3 to 6, inclusive, show synthetic cast irons, crucible melted, each at the same magnification. Fig. 4 shows the normal structure of pearlite and graphite found in ordinary engineering irons. Fig. 3 shows a structure consisting of fine or supercooled graphite and ferrite which occasionally has been produced by superheating cast iron. The structure in Fig. 3 did not obtain over the whole of the bar, but existed in substantial quantities in the normal pearlite-graphite structure.

Melting Causes Variations

These two irons were virtually of the same composition, as shown in Table II, and cast in bars of the same size. Therefore, factors of composition and rate of cooling were constant. The differences in structure are due to differences in melting conditions, which have been demonstrated to have profound influences on the product. Those differences introduce a third influence on properties, unforeseen changes which are capable of explaining many of the anomalies of behavior from which cast iron suffers. The present purpose is served by demonstrating these differences without discussing the reasons for them. Dr. Norbury has evolved a theory to explain why graphite flakes below a certain critical size become associated with ferrite rather than with pearlite, and above this size pearlite may be associated with every size of graphite up to the coarsest obtainable from a given size of section and composition.

Most of the observations made on these irons can be explained tentatively by assuming that the irons crystallizing in the ferrite, fine graphite, system are initially free from graphite nuclei, and those irons crystallizing in the pearlite, normal graphite, system are not free from nuclei. In the former case, the melt is supercooled and the graphite appears spontaneously throughout the mass, while in the latter case the flakes build up on the existing and never completely dissolved nuclei, or flakes join others to form longer flakes. It has been possible to melt a pig iron and compel it to solidify in either system at will, according to whether nuclei were present or absent. Such results are given in a paper by A. L. Norbury and E. Morgan, *Journal*, Iron and Steel institute, Great Britain, Vol. 121, I, 1930.

Figs. 5 and 6 similarly represent two structures from irons of similar compositon, but higher in silicon than Figs. 3 and 4. Fig. 6 shows the usual ferrite, normal graphite, and Fig. 5, ferrite, fine graphite, as shown in Fig. 3. In the latter case the structure occupied the whole area of the bar. A wide variety of mechanical tests have been made on irons of similar compositions in both systems. There are practical difficulties in rendering an iron completely nucleus-free, and most of the irons containing ferrite, fine graphite structure, are mixed with pearlite, normal graphite structure.

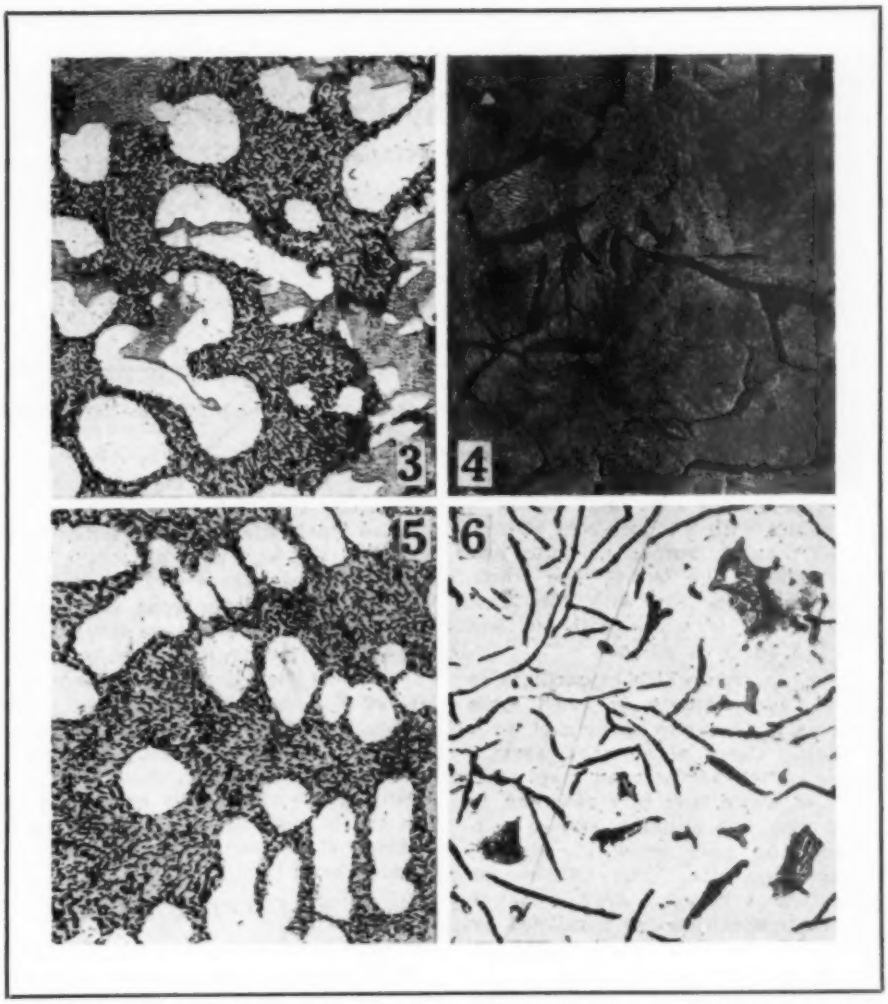


Fig. 3—Gray Cast Iron, Medium Silicon, Crystalized in Ferrite-Fine Graphite System, 200 Diameters. Fig. 4—Same Crystalized in Ferrite-Normal Graphite System, 200 Diameters. Fig. 5—Gray Cast Iron, High Silicon, Crystalized in Ferrite-Fine Graphite System, 200 Diameters. Fig. 6—Same Crystalized in Ferrite-Normal Graphite System

Irons composed wholly of pearlite, normal graphite, have high mechanical strengths, while those wholly of ferrite, fine graphite, appear to have strengths comparable with the pearlitic irons. They also are metallurgically stable. However, an iron of mixed structure is definitely weaker mechanically than an iron of either system alone. Tensile, transverse, repeated impact, brinell and machining hardness, and shear tests, show that the mixed structures are weaker and softer than the all-pearlitic irons. The ferrite, fine graphite structure, iron is markedly darker to the eye and more sooty in appearance than the pearlite, normal graphite structure, iron, having a gray, steely fracture.

The combined carbon content forms an index of the extent to which the structure is mixed. An all-pearlitic iron has the eutectoid percentage, which in an all-ferritic iron the value is low. Mixed structures show intermediate values, according to the percentage of pearlite present. These points are illustrated by Table I, which gives the mechanical properties of the irons shown in Fig. 3.

Table I shows the high strength of the pearlite, normal graphite structure, indicated by all the tests. Fig. 6, a higher silicon iron of similar graphite formation, is consistently weaker and softer, as would be expected. Fig. 5, consisting wholly of ferrite, fine graphite, is of the same order as Fig. 4, the pearlite, normal graphite, iron, but it markedly weaker on impact. Fig. 3, which should be of the same order as Fig. 4, is low because the structure is mixed. Fig. 5 has a higher brinell hardness than Fig. 3 due to the hardening effect of additional silicon in solution.

Those broad differences are of great practical importance because, in the ordinary processes of manufacture, it appears to be difficult to get an all-ferritic, fine graphite, structure. However, examples of mixed structures are found repeatedly in commercial pig irons and castings. A number of cases of difficulty in practice have been found to be associated with mixed structures. Another most important difference is the fact that the

Table I

Tests Showing Physical Properties

(Figs. 3-6 inclusive)

	Transverse, lbs. per sq. in. (1.2 in. bar)	Tensile, lbs. per sq. in. (1.2 in. bar)	Brinell (1.2 in. bar)	Repeated impact (0.875 in. bar)
Fig. 3	51,800	32,300	207	Mottled
Fig. 4	89,100	52,500	241	3,476
Fig. 5	77,500	44,000	235	235
Fig. 6	56,700	28,700	178	150

ferrite, fine graphite, irons, in spite of their low combined carbon, are much more sensitive to chilling, as shown by Figs. 1 and 2. Thus a 1.2 inch bar with 3.0 per cent total carbon is just white with 0.85 per cent silicon, in the pearlite, normal graphite, system while in the ferrite, fine graphite, system an iron with the same total carbon is white with no less than 1.3 per cent silicon.

Thus, an iron which crystallizes as ferrite, fine graphite, is much more disposed to troubles associated with chilling. Cases of so-called *inverse chilling* often are nothing more than areas of white iron corresponding to the ferrite, fine graphite, system, surrounded by gray areas of pearlite, normal graphite. The differences noted above between gray irons of similar composition are paralleled by differences between white irons of similar composition, in which, in the case corresponding to the super-cooled system, the eutectic is a fine, dispersed structure, whereas in the case corresponding to the normal system the eutectic is a coarse, coalesced structure. The mechanical properties obtained from both white and white heart malleable cast irons are superior in the super-cooled to those in the normal system.

It appears that, except in a few cases where a super-cooled structure is wanted for special purposes, gray-iron founders should aim at producing the normal system and white or chilled iron, and white-heart malleable founders, the super-cooled system. There appears no reason why this should not apply equally to black-heart malleable cast iron. There is definite scientific evidence to show that composition, even in a single size of bar, does not determine structure, so that analysis alone is not necessarily a reliable guide to mechanical properties. This confirms the principle previously adopted in Great Britain of avoiding incorporation in specifications of definite limits of analysis.

Mechanical results depend far more upon melting conditions. Small differences in composition now are regarded as of minor importance. Furthermore, a particular composition may restrict a maker's use of raw materials and may stifle research directed toward getting better results from compositions outside the specification.

Hence, the principle in Great Britain is to leave the maker to obtain definitely specified mechanical test results. Incidentally, these results may explain the tenacity with which British founders adhere to fracture as a guide in buying pig irons, even when they have the analysis as well, for pig containing ferrite, fine graphite, structures, will show dark areas where this structure occurs. Chilled pig iron also may show the latter structure, particularly at the edges. When the structure is pearlitic, results on remelting are affected by graphite size in the pig, which is capable to some extent of assessment by fracture examination.

Engineer Is Satisfied

Thus, a criterion is reached that is satisfactory to the engineer, namely, mechanical tests. As the user or buyer, his wishes carry great weight and are not likely to be overruled. Whatever use may be made of foundry or laboratory tests as auxiliaries, main concern must be with mechanical tests. Proper correlation will do much to completely justify their use on fundamental grounds. Before considering them, it is necessary to consider more fully the influences affecting mechanical properties.

It is generally accepted that composition and rate of cooling are determining influences on the mechanical properties of cast iron, and that the existing methods of control, by which silicon content is suited to a particular dominating thickness, embody the principle involved. The changes brought about by variations in phosphorus are well known, although the role of manganese, in relation to sulphur, has been much debated. It recently has been demonstrated by A. L. Norbury, *Proceedings*, Institute of British Foundrymen, Vol. 22, 1928-29, that manganese tends to graphitize gray iron up to a limit of about 0.3 per cent manganese in excess of the quota required to satisfy the sulphur as manganese sulphide; after that point, manganese tends to harden gray iron. The former action is indirect, due to the removal of the potent carbide-stabilizing action of sulphur, and the latter is the normal carbide-stabilizing action of manganese. There is evidence that this is equally true of white-heart and black-heart malleable, although the curve of change connecting combined carbon content with manganese content is so flat that opinions may differ as to the precise manganese value at which, other things being equal, the metal is at its softest.

Variations in rate of cooling are affected by considerations other than the mass and disposition of metal in the casting, its specific heat and thermal conductivity. The rate is affected by the pouring temperature, mold temperature, and the mass, specific heat and thermal conductivity of the mold material. In a given case, factors other than thickness usually can be kept reasonably constant. Therefore influence of variations in rate of cooling can be studied by testing bars melted under the same conditions and of the same compositon, but cast in a range of sizes.

Variations in melting conditions influence the properties of the metal so markedly that they transcend such minor differences in composition as inevitably occur in ordinary practice.

Table II

Chemical Analyses of Test Bars

Reference	T.C.	C.C. on 1.2 in. bar.	G.C. 1.2 in. bar.	Si	Mn	S	P
Fig. 3	2.91	0.62	2.29	1.82	0.67	0.03	0.03
Fig. 4	2.94	0.80	2.14	1.70	1.00	0.03	0.03
Fig. 5	2.81	0.14	2.67	4.53	0.98	0.03	0.03
Fig. 6	2.71	0.17	2.54	4.46	1.10	0.03	0.30
Table 4, Iron A	3.2	1.00	2.20	1.37	0.94	0.09	0.18
Table 4, Iron B	3.5	1.02	2.48	0.98	1.01	0.09	0.21
Fig. 7, A, B, C	3.51	0.78	2.73	2.03	0.52	0.07	0.04
Fig. 8, A, B, C, D, E	3.53	1.04	2.49	1.03	0.35	0.11	0.40
Fig. 9 A, B, 17A, B, C	3.57	.....	.....	1.58	0.52	0.10	0.65
Fig. 10 A	3.55	.....	.....	1.95	0.50	0.08	0.72
Fig. 10 B	3.71	.....	.....	1.29	0.62	0.09	0.59
Fig. 10 C	3.50	.....	.....	0.68	0.35	0.18	0.64
Fig. 12 A	2.89	.....	.....	1.88	0.99	0.10	0.23
Fig. 12 B	3.09	.....	.....	0.90	0.34	0.14	0.26
Fig. 12 C	3.46	.....	.....	1.57	0.45	0.10	0.43
Fig. 12 D	3.37	.....	.....	2.21	0.64	0.07	0.56

These variations, not readily recognizable in practice, are responsible for many anomalies met in foundry practice. In a given foundry they may be due to atmospheric variations; changes in coke supplier or variations in supply; change in raw material supply, such as pig iron and scrap; changes in melting practice, such as the use or disuse of ferroalloys; or variations in richness or leanness of ferroalloys, even if amounts used are adjusted to get the same composition, for ferroalloys differ markedly in their carbon content and capacity for throwing carbon out of solution; variations in pouring temperature and general surface practice, etc.

There may be differences between foundries due to methods of charging, furnace design, raw materials, fuel, fluxes, the method of make-up of charge, use of ladle additions, etc., even when they aim at the same ultimate compositon and mechanical properties. Internationally, there are important differences in fuels and ferrous raw materials, the effects of which often are not appreciated. The magnitude of the effects of these conditions and their wide variety are quite sufficient to justify the belief that every foundry, and even every casting, forms a case to be studied by itself. If the nucleus theory is correct, they operate by influencing the size and distribution of graphite, and, in cases where the graphite size falls below a critical minimum, by producing a complete change in structure.

As an illustration of the effect of varying one of the normally operating group of melting conditions on irons of the same composition, two mixtures calculated to give the same composition in the casting were cast from the same cupola in bars 1.2 and 2.2 inches in diameter. The first charge was made up of equal proportions of steel and white iron, with enough 12 per cent ferrosilicon and ferromanganese to yield a strong gray iron. The second charge was made up of the same materials, except that 40 per cent ferrosilicon was used instead of the 12 per cent, the proportion being lowered to give the same silicon content in the melt.

Table IV

Mechanical Properties of Test Bars

Diam. of bar, inches.	Transverse Test — Rupture, lbs. per sq. in. A	Rupture, lbs. per sq. in. B	Deflection, in. on 18 in. centers. A	Deflection, in. on 18 in. centers. B	Tensile test, lbs. per sq. in. A	Tensile test, lbs. per sq. in. B
1.2	72,500	70,000	0.24	0.24	45,000	40,300
2.2	64,250	59,800	0.19	0.22	35,800	33,400

Test Results Are Changed

Unfortunately, the silicon contents differed somewhat in the two melts, but the illustration is strengthened thereby, because the higher-silicon iron is the stronger mechanically. The analyses are given in Table II and the mechanical properties, Table IV. A simple change in raw material supply has produced a change in test results that is consistent and by no means insignificant. Micro-examination revealed, in addition to the slightly larger amount of graphite in *B*, a coarser graphite structure, although both were pearlitic. The influence of melting conditions can be studied by testing bars of the same composition and of the same size, or range of sizes, melted with appropriate variations in the conditions of melting.

Two conditions generally regarded as affecting composition are treated most conveniently as concerning melting conditions. One is the effect of graphite content. It is, in a measure, a function of melting conditions because, whatever the original total carbon content in an iron, the melting conditions will determine whether there is a carbon pick-up or a carbon loss, and how far this changes with remelting. MacKenzie, *Proceedings*, Institute of British Foundrymen, Vol. 20, 1926-27, has shown that, irrespective of the total carbon content of the original charges, a given melting furnace tends to produce, and on sufficiently repeated melting will produce, a total carbon content peculiar to the furnace. Furthermore, the distribution of the graphite has an important influence on the structure, and this, as previously shown, is determined not by initial compositon but by melting conditions, largely, the melting temperature and the time the metal is held at that temperature. For the same reason, the use of steel or low-carbon scrap as a constituent of the melt, must be regarded as altering the conditions of melting rather than composition.

In view of the attempts frequently made to associate the properties of cast iron with the sum of total carbon and silicon, or some fraction of the silicon content, it should be noted that correlations are likely to be established only for one set of melting conditions. Any attempt to do so for irons produced under various conditions fails, because it is impossible for any such formula to take into account the form as well as the quantity of graphite present.

The author *Journal*, Iron and Steel institute, Great Britain, Vol. 118, II 1928, has found such correlations when, melting conditions are maintained constant. It seems probable that, when a set of melting conditions remains constant, the form of graphite distribution remains approximately the same. Similarly, many attempts have been made to establish correlations between different types of mechanical tests, whether such tests measure the same basic property or not. Individual investigators have no difficulty in establishing pairs of correlations for irons made from the crucible or from the same cupola, but they do not hold universally for all conditions of melting.

Table III shows at once the number and the range of correlations established by individual investigators; and if the equations for any pair of tests are plotted, the variations are striking. Indeed, they indicate the

(*Concluded on Page 70*)

Table III

Correlated Values of Tests

Tensile and Shear

T=0.92S—1.2	(Audo)
T=0.9S —1	(Le Thomas)
T=0.75S	(Est Rly.)
T=0.63S	(Planas)
T=0.54S	(Herman)
T=0.59S	(Si < 1.6, Pisek)
T=0.92S—6.8	(Si > 1.6, Pisek)
T=0.854S	(Rudeloff)

Tensile and Brinell

T=0.13B — 8.25	(Portevin)
T=0.11B — 4.23	(Schuz)
T=0.17B —17	(Rudeloff)
T=0.2B —20.5	(Rudeloff II)
T=0.17B —20.7	(Pisek)
T=0.045B+ 3.2	(Herman)

Compression and Brinell

C=0.38B—34.3	(Le Thomas)
C=0.32B— 3.2	(Portevin)

Tensile and Transverse

T=0.5R	(Jungst)
T=0.5R to 0.55R	(B. C. I. R. A.)
T=0.475R	(Rudeloff)
T=0.43R	(Pisek)
T=0.49R	(Bach)

Compression and Tensile

C=2.5T+18	(Portevin)
C=4T	(B. C. I. R. A.)

Compression and Shear

C=3S+3	(Le Thomas)
C=2.85S	(Herman)

Shear and Brinell

S=0.13B—12	(Le Thomas)
S=0.08B	(Ferrer)
S=0.29B—35.6	(Pisek)
S=0.15B—16	(Audo)

T=Tensile (tons per sq. in.) C=Compression (tons per sq. in.)
R=Transverse (tons per sq. in.) S=Shear (tons per sq. in.)
B=Brinell (3000/10/30)

Fundamentals of

FOUNDRY PRACTICE

Various Elements Entering the Composition and Their Effect on the Quality of Cast Iron Are Described

By Ivan Lamoureux

Interpreted in the Light of American Practice by Pat Dwyer

Part XX

PIG iron is obtained from blast furnaces through the reduction of iron ore and is either white or gray cast iron, according to circumstances The same applies to the cupola. When charged with the proper raw materials a white cast iron may be obtained.

The difference between cast iron and steel lies principally in the carbon content. Steel contains less than 1 per cent of carbon and cast iron from 2½ to 4 per cent. When steel is melted in a cupola, with the metal in contact with the fuel, some of the carbon of the coke unites with the iron so that it amounts to between 2.50 and 3.00 per cent.

When the cast iron is liquid, the carbon is in a combined state. Slow cooling favors the formation of graphite. Rapid cooling or chilling produces greater proportions of combined carbon, the total carbon remaining the same.

Silicon Required

Silicon is an important element in gray iron castings. The proportion in small castings which require machining, amounts to around 2.50 per cent, in large castings for example with a thickness of 4 inches, the percentage of silicon may drop below 1 per cent. Silicon favors the crystallization of graphite. It confers on the iron a more open grain and consequently a softness in machining and a reduced shrinkage. It also makes the iron run more readily.

Manganese opposes crystallization of the graphite, makes the iron more close-grained and increases shrinkage. In some cases it increases the strength of the iron as it makes it more close-grained, and tends to remove sulphur. It has desirable qualities in the manufacture of hardened castings.

Phosphorus imparts great fluidity to the iron. This advantage is turned to account in casting thin sections, thin hollowware, stove castings and ornamental iron work. Phosphorus diminishes the strength of cast iron, hence it is held to a minimum in castings requiring great strength.

Effect of Elements

IN THIS, the first part of the sixth section, the author discusses the various elements entering into the composition of the metal known as cast iron and how a variation in the relative amounts of these elements affect the physical characteristics of the metal in the casting. He touches upon the shrinkage and expansion feature and then discusses coke, limestone, fire brick, clay lining and wood required for the cupola operation. The various classifications of iron in the raw state are described, pig iron, scrap iron, steel scrap and iron alloys. Formulas are presented for calculating the charge under various conditions to meet any given specifications. Attention is directed to the fact that certain changes take place in the composition of the iron during the melting process.

Sulphur as a general rule is considered a detrimental element in cast iron. However, Hurst in *Metallurgy of Cast Iron* states that sulphur up to 0.20 per cent in ordinary foundry irons containing about 2.0 per cent silicon, does not exert a serious influence. When quite high it increases hardness and consequently shrinkage. It causes blow-holes and hard spots, and is of no use except in hardened cast iron pieces as it increases the proportion of combined carbon.

For some years past, small proportions of alloys containing nickel,chromium, titanium, etc., have been used to increase the strength of cast iron. Sometimes traces of copper are found.

It is not a simple matter to control at will the proportion of the various elements contained in cast iron. The different kinds of cast iron contain all the elements in varying proportions and it is only through a judicious selection that the desired results are obtained. Later we shall see the manner of preparing a melting charge.

After iron is melted and poured into the mold, it starts to solidify before crystallizing. It is subjected to one or more expansions before reaching a final shrinkage. Therefore it increases in volume before attaining its normal size.

The shrinkage varies according to the quantity and form of the carbon. Where the combined carbon predominates, the grain is close, the shrinkage is great, sometimes ¼-inch to the foot. When the graphitic carbon is present in strong proportion the shrinkage is small, approximately 1/10-inch per foot.

Use Good Coke

Foundry coke should be of the best quality. It should show a uniform fracture of a light gray color and should not crush when pressed underfoot. If it is black, it is an indication that it has not been thoroughly coked and therefore should be rejected. A lot of coke dust or small pieces in the bottom of the car indicates a lack of hardness and the use of such coke is dangerous. The hardness should not be excessive. Some cokes containing silica are hard yet they are of poor quality. Coke should break readily under a blow of a hammer and break without reducing to a powder. The ash content should not exceed 12 per cent and the sulphur 1.0 per cent. When exposed to the air in rainy weather coke may absorb moisture up to 30 per cent.

The difference between the price of good coke and that of ordinary coke never can compensate for the great advantages of a first quality product, a hot melt, pure iron, with the inconveniences of a poor quality product causing cold and dirty iron, a choked cupola, etc. Some foundrymen buy first quality coke for the cupola and buy ordinary coke for the dryers. That is still false economy. The efficiency of such coke is extremely low and it proves more expensive than

quality coke in the final analysis.

Coke cinders, the sand on the pig-iron, and rust and other deposits found on scrap iron, form a thick slag which might stop the operation of the cupola. By adding a certain quantity of limestone, from 2 to 5 per cent of the weight of the iron depending on whether the iron is clean or dirty, this slag is made fluid. It flows readily and insures a comparatively clean cupola. Furthermore, limestone tends to eliminate sulphur. The slag layer which rises to the top of the iron bath protects it against oxidation, resulting from the air supplied by the blower. The limestone should be as pure as possible.

The lining of the cupola is an important item. The foundryman should be interested in employing only first quality material. Even the best brick poorly laid will give but halfway results. The brick should be laid carefully with thin joints and carefully watched to see that there are no rough spots after the job is finished. Poor quality bricks will wear away fast. This wearing away of the brick lining increases the amount of slag and the operation of the plant becomes irregular.

Recondition the Lining

Some foundrymen prefer a ganister lining, rammed between a form and the shell of the cupola. This is known as a monolithic or one piece lining. One of the advantages claimed for this form of lining is that no joints are present as in a brick lining. It is generally admitted that the joints are the weakest point of the lining, the point which offers the least resistance to attack.

After each heat, that part of the lining surrounding the melting zone, is repaired and brought back to shape with a coating of highly refractory clay or other high quality daubing material. This applies to either the brick or monolithic lining. In practice it has been found that this daubing should not exceed 1-inch in thickness. Where a greater thickness is needed, brick bats or splits bricks should be bedded in place.

Iron charged into a cupola to be converted into castings is composed of pigs from the blast furnace, scrap iron from old machinery or defective castings, risers, shrink-heads, core-frames, etc., scrap steel, pieces of rails, springs, cast steel, the various iron alloys, such as ferrosilicon, ferromanganese, etc.

Pig iron usually is sold by number, although there is no uniformity of classification, which varies in different countries. Appearance of the fracture gives a fair idea to quality although it would be hazardous to form one's conclusions on this basis alone. At some blast-furnaces the pigs are poured in sand, while at others the iron is poured in metal molds. Naturally, in the latter case the iron presents a much closer grain due to the more rapid cooling. Sows or metal of considerably larger cross-section than the usual pigs, always show a more open texture than the ordinary pigs due to slower cooling. Since they all come from the same cast, the iron will be the same after it is remelted. In the larger foundries a laboratory with a control service makes an analysis of the pig iron received to be sure of the composition. The analysis of the iron is supplied by its seller and furnishes a base for determining the price by the showing of its quality.

Pig iron for use in gray iron foundries contains a large proportion of phosphorus. This iron is fluid, soft and will run in the thinnest sections. Moreover it remains hot for a long time and may be poured at fairly long distances from the cupola. Following is given an average analysis of such an iron. Ordinary iron for castings contains: Silicon 2 to 2.50 per cent, manganese 0.50 to 0.75 per cent, sulphur 0.02 to 0.05 per cent, phosphorus 0.50 to 0.75 per cent. European irons show higher phosphorus, from 1.50 to 1.75 per cent. The more silicon an iron contains the softer it will be, always remaining of course within reasonable limits. It is the essential element which characterizes the number of the iron.

In the phosphoric irons one can obtain the whole range of hardnesses starting with the softest iron containing 3.50 per cent silicon, up to the hardest iron with a silicon content of 1.50 per cent. The essential difference between hematite iron—known in America as bessemer iron — and ordinary iron is the percentage of phosphorus; in fact, the amount of phosphorus in hematite iron is insignificant. This increases the strength but somewhat diminishes the fluidity. In the hematite irons one also has the whole range of hardnesses from the real gray iron to the white iron.

Typical analysis of a gray hematite iron shows: Silicon 2 to 2.50 per cent, manganese 0.50 to 1 per cent, sulphur, 0.02 to 0.05 per cent, phosphorus, 0.03 to 0.08 per cent. Foundries which specialize in chilled iron rolls and other special castings use pig iron of extreme purity, which usually comes from England, Sweden or America.

According to American custom, pig iron is classified under four heads: 1—Cold, warm or hot blast. 2—Coke, anthracite or charcoal. 3—Sand or machine. 4—Basic, bessemer, malleable, foundry or forge. Basic iron primarily means iron with low silicon. The standard shows silicon under 1.00 per cent and sulphur under 0.05.

Bessemer iron means iron with low phosphorus and low sulphur. Standard bessemer contains from 1.00 to 1.25 silicon and sulphur under 0.05 per cent, but the grade is based essentially on low phosphorus. Irons with extra low phosphorus and variable silicon sometimes are designated low phosphorus irons.

Foundry and forge irons embrace practically everything in the way of ordinary iron. The grades are subdivided on the basis of silicon and sulphur content. The accompanying table shows how foundry iron is classified in the four main American districts.

As a rule charcoal iron is not graded according to this table, but is sold by fracture, by analysis, by chill test or by a special system of grading according to the custom of the maker and demand of the buyer.

Scrap iron falls into four general classifications. First choice machinery scrap consists of machined parts of machine tools, etc. Second choice scrap iron includes scrap pipes, base plates, brake shoes and in general all gray cast iron parts that have

Table III

Classification and Grades of Foundry Iron

District	Designation	Silicon Per Cent	Sulphur Per Cent
Southern Points	No. 1 Foundry	2.75-3.25	0.05 and under
	No. 2 Foundry	2.25-2.75	0.05 and under
	No. 3 Foundry	1.75-2.25	0.06 and under
	No. 4 Foundry	1.25-2.00	0.07 and under
	Gray Forge	1.25-1.75	0.08 and under
	No. 1 Soft	3.00 and over	0.05 and under
	No. 2 Soft	2.50-3.25	0.05 and under
Eastern Points	No. 1X	2.75 and up	0.030 and under
	No. 2X	2.25-2.75	0.045 and under
	No. 2 Plain	1.75-2.25	0.05 and under
	No. 3 Foundry	1.25-1.75	0.065 and under
	No. 2 Mill	1.25 and under	0.065 and under
	Gray Forge	1.50 and under	0.065 and up
Central West	No. 1 Foundry	2.25-2.75	0.05 and under
	No. 2 Foundry	1.75-2.25	0.05 and under
	No. 3 Foundry	1.75 and under	0.05 and under
	Gray Forge		0.05 and over
Buffalo	Scotch	3.00 and over	0.05 and under
	No. 1 Foundry	2.50-3.00	0.05 and under
	No. 2 Foundry	2.00-2.50	0.05 and under
	No. 2 Plain	1.50-2.00	0.05 and under
	No. 3 Foundry	1.50 and under	0.05 and under
	Gray Forge		0.05 and over

not been machined, and are used for recasting into similar parts, or into particularly close-grained iron. The third class covers burnt scrap iron, that is, old iron stove frames, grates, pots and all old iron in general that has been oxidized by fire. Special grades of scrap iron are cast into pigs according to the uniformity of their composition their special quality.

Scrap iron of inferior quality should be eliminated when dealing with delicate castings, and only should be used when the nature of the castings permits. A deplorable existing practice permits classifying scrap iron according to its fracture only.

Use Heavy Scrap

Foundrymen who make small castings, pick up parts of flywheels or large machinery parts. In the thick section the iron crystallizes into coarse grains. The same iron recast in a thin section will be nearly white and in every case will be extremely hard. Therefore it is preferable to use scrap iron approximately near the size of the casting to be made from it. The foundryman who has to cast small machine parts should buy scrap iron parts that have been used on sewing machines, motorcycles, small machine tools, small motors, gears, textile machines, etc.

One who has to make large castings preferably should select parts of fly wheels, large cylinder bases, large machine tool parts, etc. Cast iron poured into thin sections always will have a close grain. Even a close-grained iron cast into heavy sections generally will have a coarse grain.

Iron left over after each day's heat is remelted each day and generally enters into the mixture on the same basis as scrap iron. Where castings are poured from special mixtures, the gates, risers and other resulting scrap should be set aside so as not to become mixed with the other metal. Furthermore it is advisable to clean this scrap in a tumbling barrel or sand blast. The cleaning considerably reduces the amount of coke used in melting and considerably increases the life of the cupola lining.

The alloy used most extensively is ferrosilicon in which the silicon content varies from 10 to 80 per cent. Up to 10 per cent it is placed in the cupola with the regular charge. The 80 per cent material is placed in the spout or in the pouring ladle. It is used especially for softening the cast iron but it is obvious that its use almost always involves extra expense. It is indispensable in the manufacture of semisteel. In some instances it enters in the proportion of from 15 to 20 per cent, the remainder consisting of good steel scrap. In the pouring ladle it causes a reaction which raises the temperature of the cast iron, provided this iron is still extremely hot. If the iron begins to turn sticky, the action of ferrosilicon is more detrimental than useful.

Knowing the composition of the various raw materials available and the composition of the metal to be obtained, the purpose of calculating the charge is to ascertain the quantities of each of the raw materials necessary to obtain a mixture having the desired composition. Theoretically this problem generally is susceptible of various solutions. In practice the most economical solution is desirable, that is, the one involving the use of as inexpensive raw materials as possible.

To simplify the calculations, generally they are not extended beyond determining the proportion of silicon to be obtained. That is why the proportions of each of the raw materials is determined in advance. One has to allow for the amount of foundry scrap to be melted, a certain proportion of other scrap, and also the need for using a certain proportion of some other kind of iron to introduce into the mixture the desired proportion of some particular element, such as phosphorus or manganese nickel, chromium, etc. Then it is only necessary to determine the proportions of the other elements, a result easily arrived at after some investigation.

It is absolutely useless to endeavor to obtain strictly exact figures. In the usual sampling process, analysis of the raw materials only gives an average of their true composition. The formulas showing the composition of the castings are merely approximate.

It is also necessary to bear in mind that iron, in passing through the cupola undergoes certain modifications in its compositions.

Silicon and manganese diminish by about 25 per cent of their content. Phosphorus does not change. Sulphur increases by about 0.03 per cent. The carbon increases or decreases, depending on the rate of fusion, but in practice it may be assumed that it does not change at all.

Where East and West Meet on a Common Footing

By C. H. Gale

AFTER rounding out a period of 50 years' active connection with the foundry industry, C. H. Gale, retired a few years ago and has since indulged a long repressed desire to see the out of the way and far corners of the earth. However, he still retains the foundry viewpoint as may be noted in the following comment which accompanied the photograph of Buddha taken on a recent trip through Japan:

"Of the several great Buddhas in Japan I am enclosing a photo of the finest and most noted one at Kamakura. This statue was cast in 1252 A. D., in a foundry that was built near the spot where the statue now stands. The statue is 50 feet from the base to the top of the head and was cast in five sections. The joints between the parts may be seen by an observer although they do not show in the picture. It is claimed that 200 tons of metal were required to cast this figure.

A 200-ton bronze statue of Buddha at Kamakura, Japan

"I have seen Japanese of the poorer class stand before this great sacred Buddha, with their eyes raised in reverence to the face of the statue. They rub their hands together and their lips move in supplication to the Great One imploring personal blessings and protection.

"Association of ideas carried my mind back to the foundry where on numberless occasions I have seen the foreman or superintendent in the same attitude before a defective casting, where the molder had neglected to anchor a core properly, to take off a necessary vent, one on which the sand had been rammed too hard or too soft, one in which he had miscalculated the amount of metal required or one in which the metal had run out where it had no business to run out. I have seen the foreman's or superintendent's lips also moving in supplication, but, you know the old saying—Kipling's I think —East is East, and West is West and never the twain shall meet! The foreman before the casting is just as sincere as the Japanese worshiper before the statue. But he employs different words, that's all!"

GERMAN FOUNDERS Discuss *Pig Iron* Containing ALUMINUM

By Hurbert Hermanns
German Correspondent, THE FOUNDRY

THE sixtieth general meeting of the German Iron Founders' association, Verein Deutscher Eisengiessereien, was held on Sept. 4 and 5, at Eisenach, the birth place of Johann Sebastian Bach, one of the most famous musicians and composers of all times. Eisenach was the home of Dr. Martin Luther for many years, the town of the world-famed Wartburg, where every year thousands of Americans go to see the historical place where Luther was defended in the times of the German Reformation in the sixteenth century.

Eisenach, Where the German Convention Was Held, Has Conserved a Part of Its Early Character

President of the association, Dr. Siegfried Werner, pointed out in his address that it was the sixth time that the German Iron Foundries met at Eisenach, the first meeting having been held in 1885. Dr. Werner recalled that, in that year, there were many difficulties in the economic situation of the German iron foundries. However, the situation then was not as disastrous and difficult as at present. Unemployment in German iron foundries is large. The number of workers among the members of the association declined from 70,506 on April 1, 1929 to about 60,000 at July 1, 1930. A great part of the remaining foundry workers are occupied only a part time. In the last few months many of the iron foundries have been closed.

According to a paper by the secretary of the association, Dr. Leidig, a deputy of the Prussian state parliament, the situation of the German industries in general and of the foundries in particular should not be considered hopeless. He believes that the rationalization work of the last few years and the modern equipment which has been installed will enable the German iron foundries to enter the coming industrial period with confidence.

Several interesting technical papers were read before the meeting. The relation between continuous foundry work, which is named in German *flowing work*, and the health and the life of foundry workers was discussed in two papers containing the results of work in the Research Institute for Labor Physiology at Frankfurt.

Dr. Ascher of the institute pointed out the surprising fact that the life and the health of the industrial population has been raised by mechanization in a measure never before known. In several moving pictures he showed the work of mechanics, smiths, carpenters of every age between 15 and 60 years. According to Dr. Ascher the transfer of the heavy work to machines is highly advantageous for the worker.

Gives Research Results

Following this paper, G. Stern, chief engineer, Frankfurt, showed the results of his special research on the effects of fatigue on machine molders. He has found that the heat consumption of the molder has been reduced by correct continuous molding and conveying apparatus and by the rationalization of the work. The term rationalization means the elimination of all unnecessary fatigue of the worker. In the course of his research Mr. Stern eliminated all unnecessary movements and arranged the molding machines in the best possible way. The conveyors have been shortened to a minimum, the single operations of the molders have been measured as well as the energy consumption of the molders in using hydraulic molding machines and hand-squeezing machines. This research work has resulted in many important alterations and modifications of the molding machines and equipment. A new form of the strike-off board of triangular section with a reinforcing metal strip on the one side has been developed. The power consumption of the molder for the strike-off operation has been reduced to about 50 per cent by this new board. The fatigue of the molder has been reduced further by employing a separate auxiliary worker for shoveling the molding sand. Mr. Stern showed by a graphical chart the increase in working capacities of the machine molders and the consumption of the worker in the form of thermal mal units. Dr. Werner explained that the results of the research work of Ascher and Stern are showing new ways for the reduction of production costs and the increase of production.

Dr. Paschke, professor at the metallurgical department, Mining and Metallurgical University of Clausthal, Germany, presented a paper on a new special foundry pig iron. Experiments extending over several years have resulted in the production of a pig iron in the blast furnace having special refining properties for use as cast iron. With this iron a slag with good hydraulic properties is produced. The iron is made from a burden composed of bauxite, limestone and rich iron ore or scrap. The iron has the following average analysis: Carbon 4.50 to 5.00 per cent, silicon 0.10 to 0.30 per cent, manganese 0.50 per cent, phosphorus 0.10 to 0.13 per cent, sulphur 0.02 per cent, aluminum 0.15 to 0.20 per cent. The aluminum is in metallic form. Its reduction is caused by the high temperatures in the lower part of the blast furnace. Obviously the aluminum plays an important part insofar as the pressure of the carbon monoxide in the iron is greatly lowered so that an elimination of the gas during the solidification of the iron

in the mold is practically eliminated.

These factors result in a refining effect on the graphite of the gray pig iron, the matrix structure of which is pearlitic. This pearlitic structure results in favorable refining qualities of the pig iron. The new special iron is added to the cupola mixtures in quantities of not less than 10 per cent. Under this limit a refining effect was not observed. Correct mixtures give a cupola iron of high mechanical strength and physical properties together with a high fluidity, though the phosphorus content of the mixture is very low. Further, piping of the iron is reduced greatly. A certain number of German foundries make use of the iron to improve the cupola mixtures and the properties of the castings they make.

Conducts Investigations

Dr. Jung has conducted tests with bars produced from cupola melts with various additions of the new special iron. The tests showed good results. Before these tests the confidence in the new iron was not great because its texture was not regular, and depended on the type of blast furnace process. Appearance of the iron was white in some cases and gray in others. However, tests showed not only improved physical and mechanical properties of the bars, but also a much higher fluidity of the iron. Dr. Jung found that an addition of 15 per cent to the cupola mixture gave the best results. Substitution of steel scrap additions for the new metal reduced the fluidity and raised the piping effect.

In the opinion of Dr. Neumark, the managing director of the Roland blast-furnace plant and inventor of the new pig iron, its favorable properties come from the chemical composition of the slag in the blast furnace. He pointed out that he is the first blast-furnace man having produced a pig iron with a slag of more than 40 per cent aluminous oxide and less than 10 per cent silica. The difficulties during the several years tests were great. Under normal conditions he has produced more than 1000 tons of the new iron in a small blast furnace. Answering a question of Dr. Werner, he said that it is not yet possible to say anything on the higher production costs of the new iron, because they will be reduced greatly under normal conditions in a larger blast furnace.

Mr. Petin said that, according to his own practical experience, the piping effect of iron castings is not caused so much by the composition of the foundry iron mixtures as by gating of the molds. He believes that an experienced molder can avoid troubles without adding special irons to the mixture.

In the last paper of the session Dr. Geilenkirchen, secretary of the association, surveyed the present technical and economic status of the German foundries. Compared with the economic position, the technical status is much better. Mechanical equipment of the foundries has been improved greatly during the past few years. Unfortunately the foundries at present are unable to secure full advantage of the better equipment. Dr. Geilenkirchen gave a resumee of the practical and research work as conducted by the committees of the association. By far the most important task of the future is to specialize production of German iron foundries. Already, many large foundries have specialized production, especially the pipe foundries, radiator foundries, and bath-tub foundries. In general the situation in these shops is not as bad as in the plants making machine and jobbing castings. Closer co-operation between the designer of the machine shop and the foundry manager is of great importance. In many cases the co-operation will improve, simplify and unify the designs, resulting in a reduction in foundry production costs. This problem is, of course, most difficult in a jobbing foundry. Dr. Geilenkirchen believes that the economic situation of the foundries also can be improved by better methods of management.

Correlation Involves Many Difficulties

(*Concluded from Page* 65)

range of variation to be expected from differing melting conditions. Such correlations are only valid for one prescribed set of melting conditions.

Simple procedures underlying investigations on cast iron tests are:

(1) The effect of variations in composition on the properties of cast iron may be studied by testing bars of the same size, cast under the same melting conditions, but with appropriate variations of composition.

(2) The effect of variations in rate of cooling on the properties of cast iron may be studied by testing bars of different sizes made under the same melting conditions.

(3) The effect of variations in melting conditions, individual or aggregate, on the properties of cast iron may be studied by testing bars of the same size and composition under varying melting conditions.

Bars specified by engineers frequently ignore the connection between properties and rate of cooling, as in calling for a large casting to be represented by a small bar, and vice versa.

Further complication is introduced by the use of a bar cast as an integral part of the casting although there may be no relation between the thicknesses concerned, or no instruction as the place of casting-on, the length of the connectors or the disposition of the bar in relation to the cooling mass of the casting. Circumstances making it impossible for him to do both, the founder often is forced to decide whether to make a good test bar, a good casting, or an unsatisfactory compromise.

The skin effect is an important consideration in mechanical tests. In some tests, such as transverse, the bar can be tested as cast or it can be machined prior to testing. In a gray bar, the metal is more open and weak at the center than immediately under the skin. The progressive removal of stock will result in a progressive weakening of the bar. This effect will be considered later, but it is common experience, which the author has repeatedly confirmed by direct experiment, that skin-machining yields a stronger bar. It may increase the transverse strength 10 per cent. Early American tests showed that the removal of 0.25 inch of stock diminished the strength; but if, say, 0.06 inch is removed on a small bar, or 0.1 inch on a large bar, the strength is markedly increased, as is the deflection.

Bars Contain Fissures

That probably is due to the fact that the skin of a green-sand bar contains minute superficial fissures which may cause premature rupture under test, and possibly a release of skin stress, of which the fissures may be regarded as evidence. Bars tested in transverse as cast are erratic in their results, while skin-machined bars are more uniform and regular. It is to the interest of the manufacturer to skin-machine transverse bars.

For a given mixture and assuming a gray structure throughout, a thick bar will be weaker, per unit of area, than a thin bar. By casting a series of bars varying diameters from the same ladle, that is, same composition and melting conditions, the author *Journal*, Iron and Steel institute, Great Britain, Vol. 118, II, 1928; *Foundry Trade Journal*, Jan. 24, 1929; and *Proceedings*, Institute of British Foundrymen, Vol. 22, 1928-29, has shown that the change in strength with size is continuous, whatever type of test be adopted.

For some tests, tensile and transverse for example, it is easy to test the bar at or near the cast size. The alteration in mass effect due to skin-machining can be disregarded, as the effect on the section is slight. For other tests, such as shear, compression, impact, and fatigue, it is impracticable to test many sizes, as this would involve a battery of machines or large machines.

Comparisons often are made between one type of test on bars at or near the cast size, and another type of test on small diameters machined from them, as if it were taken for granted that the metal behaves in the small size exactly as it does in the large size.

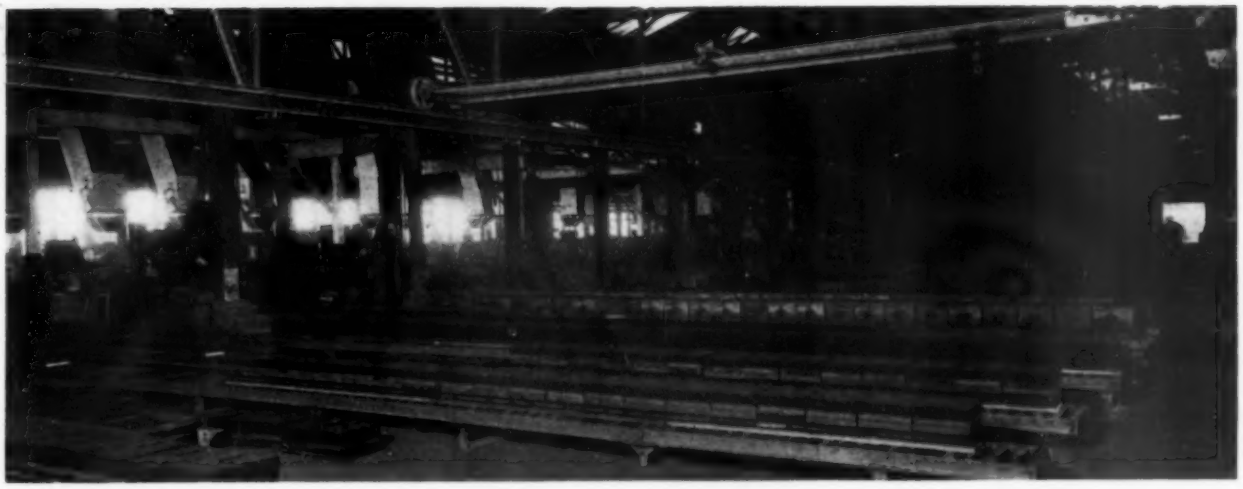


Fig. 1—General View of Conveyors Carrying Molds from Machines to Pouring Zone

Jobbing Shop Emulates Production Foundry

WHILE a great many of the large production shops throughout the country are equipped with the latest types of equipment to perform practically all operations necessary in the manufacture of castings, the mechanization of the purely jobbing shop is rather unusual. Variations in the size, class and number of castings produced often militate against the extensive use of certain types of equipment in the jobbing shop. For that reason, the success that has crowned the efforts of the Plainville Casting Co., Plainville, Conn., toward the application of mechanical equipment to practically all operations should be of special interest.

The Plainville Casting Co. is a jobbing shop producing a variety of gray iron, semisteel and high test alloy castings ranging in weight from a few ounces to 250 pounds. The output is decidedly diversified, consisting of such representative castings as winding machine parts, pressure valves, power transmission bearings, oil burners, light meter work and other small and medium size castings.

H. S. Washburn, founder and president of the Plainville Casting Co., is a member of an old New England family long identified with the metal industry in that section, notably as wire manufacturers. His grandfather and father were instrumental in starting and developing the wire industry at Worcester, Mass. Associated with Mr. Washburn in the management of the plant are the following: Howard J. Castle, vice president; John C. Alberts, production manager; and Gilbert I. Drysdale, secretary.

The growth of the company has been rapid from the day of its incorporation in 1921. The first week's

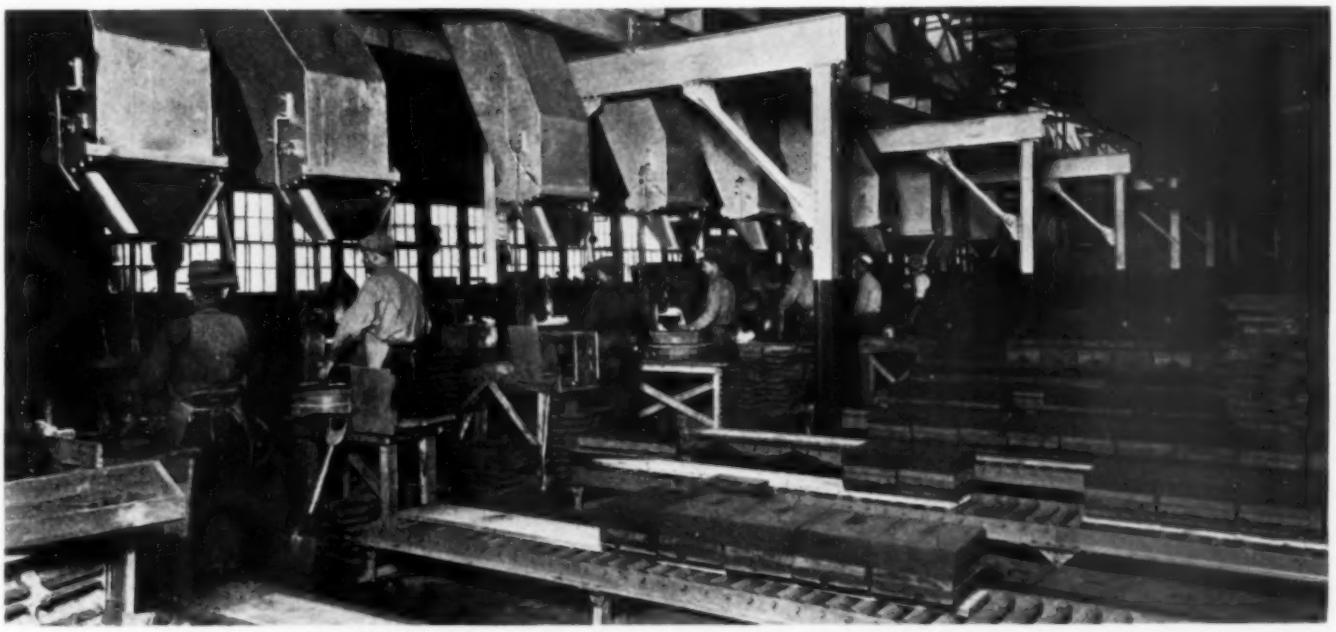


Fig. 2—Molding Machines Are Placed Under Chutes Leading from Sand Bins

payroll totaled $74.04 and of the three men who were employed by the company during the first week of its existance, two are still with the company as foremen. From the start of the business to the present time, it has been the intent of the management to offer the larger users of castings, in the territory, the facilities of a production jobbing foundry, modern in every respect. The fact that this plant has been working practically at capacity during the summer depression indicates the success that has followed the accomplishment of the aim.

Adopt Mechanical Equipment

In adopting mechanical equipment throughout the plant, the problem confronting the management was to devise a system which would include the advantages of continuous operation and embodying mechanical handling and treating of sand, delivering the sand to overhead bins and moving the molds from the molding machines to the shakeout. At the same time the system had to afford the flexibility required to take care of a variety of molds of different sizes and an average of six separate mixtures during the course of a days run.

The original survey found the shop equipped with modern production molding machines, pattern equipment designed for production molding and a continuous pouring system which had been operated successfully for more than four years. This was in part responsible for the ease with which the change was made from the old to the new method of operation.

The erection work required five weeks, during which time not a heat was lost and deliveries were made on schedule. Confronted with the production schedule, the problem of placing the foundry on a continuous molding and pouring basis was difficult. It is the usual custom to shut down the plant from Thursday night before Good Friday until the Tuesday after Easter, and that time was selected to make the final change over. During that period the molding machines were relocated under the sand bins and molding sand was run through the sand treating and sand handling equipment. The equipment was ready for operation at 7 o'clock Tuesday morning, and although the men had to get acquainted with entirely new conditions, the production for Tuesday compared favorably with that of the preceding Thursday and no perceptable increase developed in defective castings. On the third day, production bettered the output under the old methods by 3 tons.

The system comprises 18 molding stations. Each station is provided with an overhead bin holding approximately 3 tons of prepared sand. The sand is carried to the bins on a flight conveyor and is discharged from the bins into flasks on the molding machines through hand operated clam shell gates. Each molding station is provided with a roller conveyor on which the molds are carried to the pouring station, as shown in Fig. 1. In the case of snap flask molds, the

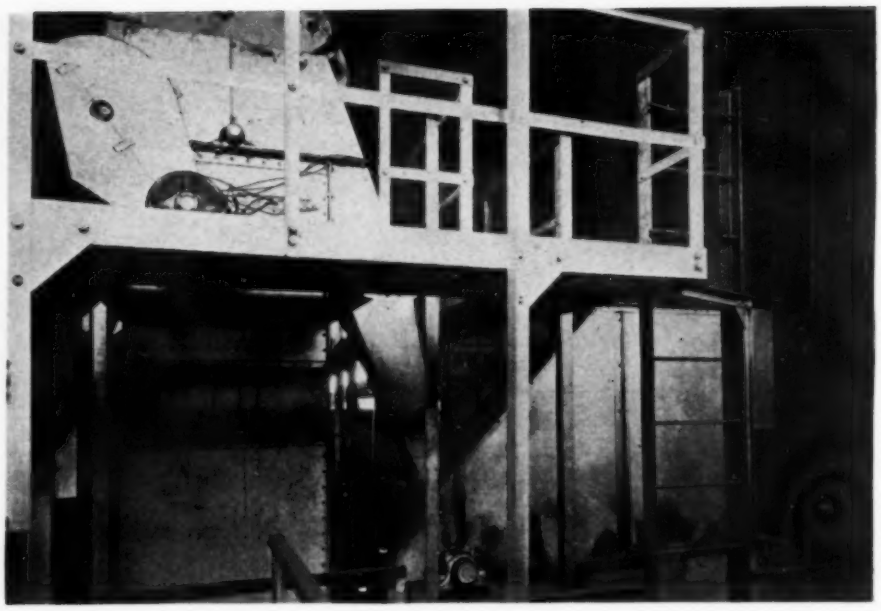


Fig. 4—Sand Is Elevated from the Conditioner and Passed Through an Aerator

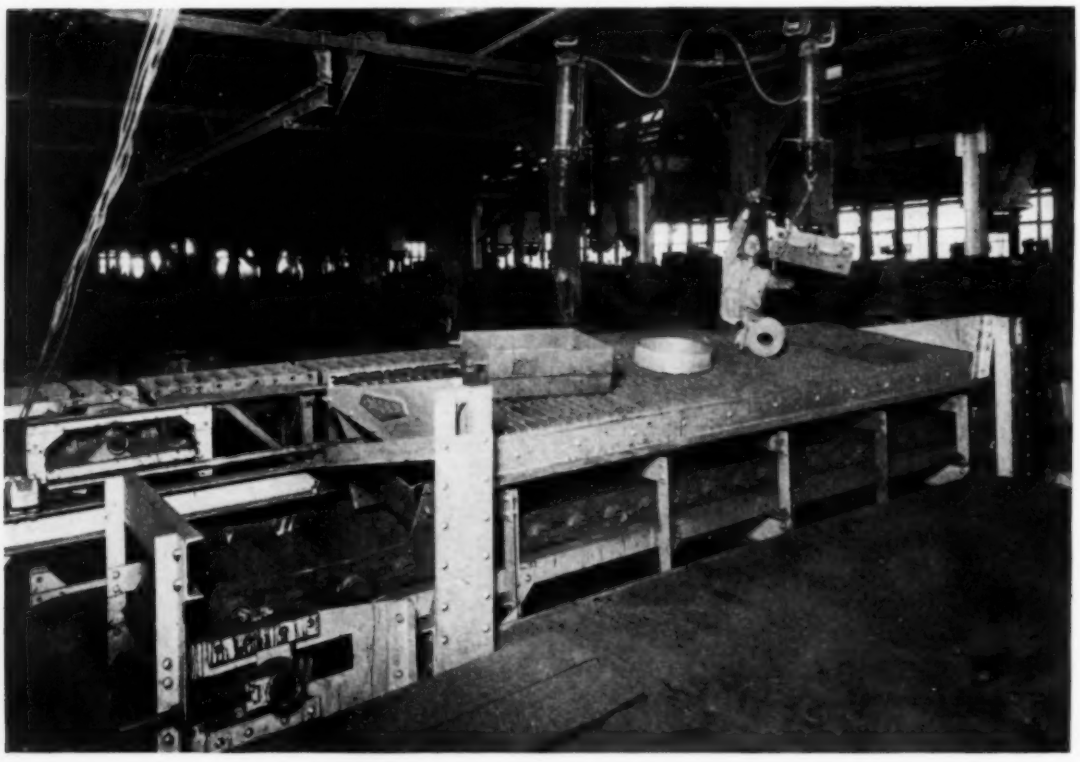


Fig. 3 — A Power Conveyor Elevates the Molds to the Level of the Shakeout Grating. Castings Slide or Are Pushed into Boxes Placed in the Immediate Foreground

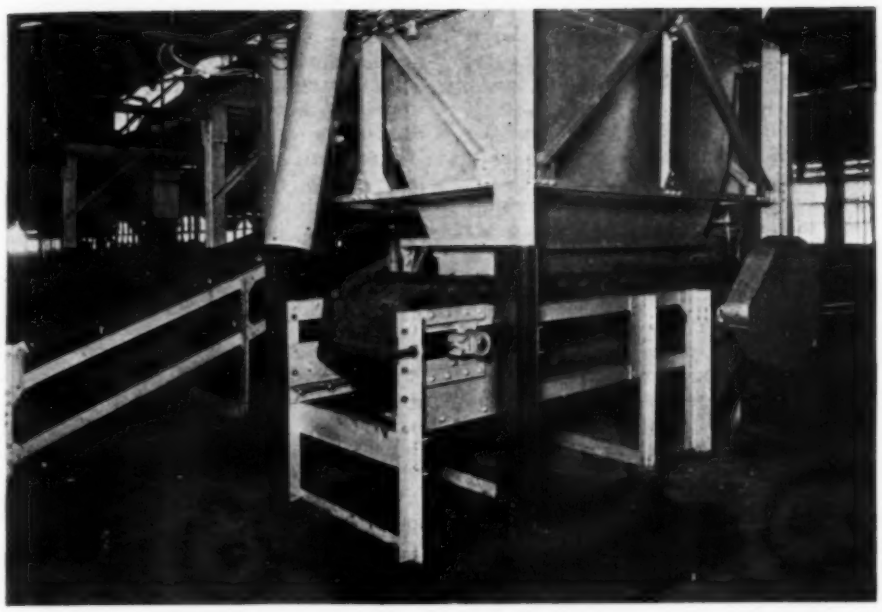


Fig. 5—Bottom of 40-Ton Storage Bin with Apron Conveyor and Drive

molder places the completed mold on the gravity conveyor immediately in the rear of the molding machine. To avoid difficulty from vibration in moving the snap flask molds, the bottom board rests on a long plank, as shown in Fig. 1, and molds are moved as a unit.

Where the cope is made on one molding machine and the drag is made on another, the drag is placed on the roller conveyor, the cores are set where required, and the cope is set in place. A variety of molding machines are used, the snap flask molds being made on jolt-squeezing machines. Where a pair of machines are used to make a mold, the drag is made on a jolt-rollover machine and the cope is produced on a jolt-squeeze-rollover type machine. All molding machines were supplied by the Osborn Mfg. Co., Cleveland and were used in the plant previous to the installation of the continuous system.

The conveyor lines leading from the molding stations are 50 feet in length. Two pouring devices, suspended from the 21-foot span runways, shown in Fig. 2, are utilized in pouring the molds after they have been moved from the molding machines. Some snap flask molds are poured with hand ladles and in the case of necessity arising from small tonnages of special mixtures of iron, the molds are poured over the entire length of the conveyor. A gangway is provided at the pouring end of the conveyors. The metal is brought from the cupolas, located along the side at one end of the shop, in bull ladles suspended from a monorail conveyor located over the gangway.

After the molds have been poured, they are transfered to a roller conveyor which runs the entire length of the system, approximately 150 feet, at right angles to the pouring conveyors and ends at the shakeout. The transfer from the pouring conveyor is accomplished by a special transfer conveyor which consists of a roller conveyor section mounted on wheels so that it may be swung or moved from one conveyor to another.

Molds Are Elevated

The roller conveyor leading to the shakeout is elevated 12 inches above the floor. Immediately before the shakeout is reached, a power operated booster elevates the molds to a level of 38 inches above the floor and places them on another roller conveyor which extends along the side of the shakeout grating, as shown in Fig. 3. The smaller molds are pushed onto the grating while two 1000-pound capacity air hoists operating on a circular track, are used to transfer the heavy molds to the shakeout grating and to shift the empty flasks to the return gravity conveyor, where they are returned to the molding stations. Bottom boards also are returned in this manner. The shakeout grating is 14 feet long and 4 feet wide, and is constructed of steel bars spaced on 2½-inch centers which rest on a rigid frame. The frame is pivoted on one side and arranged to be raised by a cam action and then dropped on an anvil. The unit is

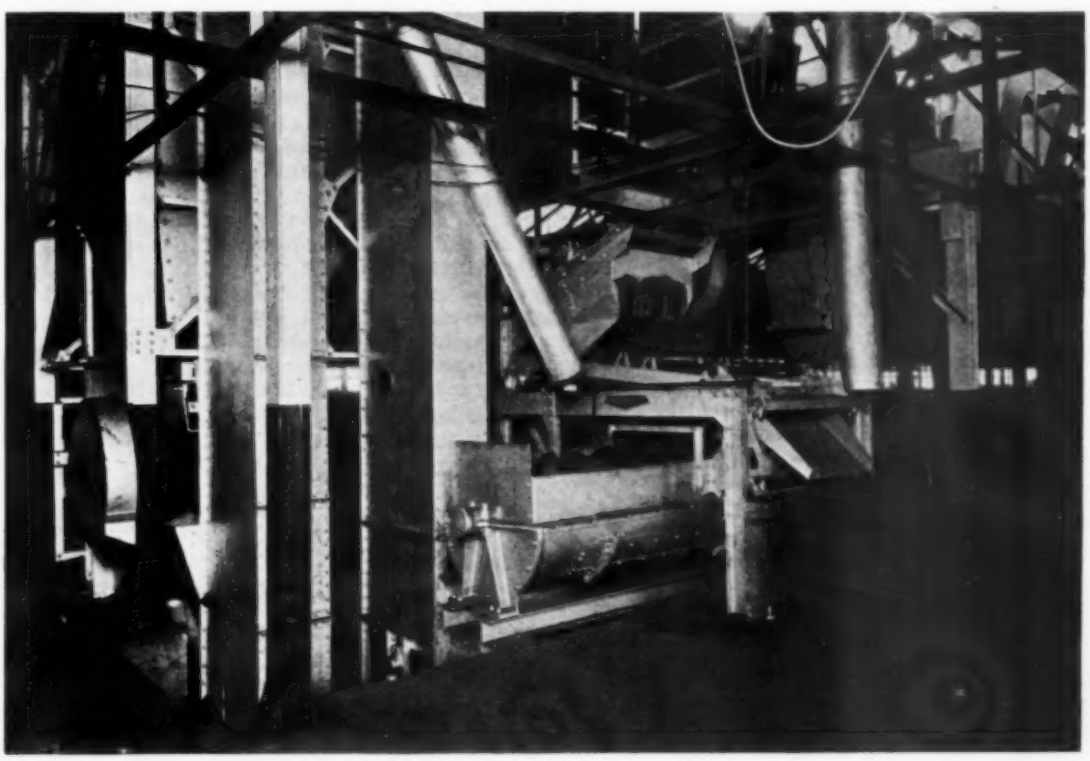


Fig. 6—Sand Passes Through the Screen and into the Pug Mill Where it Is Mixed. The Elevator at the Left Carries the Sand to the Aerator Located Above

motor driven from the power source.

The castings fall or are pulled across the shakeout grate into steel boxes, which are placed along the lower side of the grating, and then are removed to the cleaning department by an electric lift truck. The sand falls through the grating into a hopper and then is carried on a shakeout apron conveyor and discharged onto a shaking screen, shown in Fig. 5. New sand is added at the shakeout. The sand falls through the screen into a 10-foot pug mill where the water is added and the sand mixed thoroughly. The mixer is designed to mull the sand and at the same time carry it to the discharge end where it is fed into the boot of an elevator. The sand then is carried up a distance of 38 feet and discharged into an aerator which throws the sand into the air, thus giving the heat and gas an opportunity of escaping. Metal shot and other foreign substances in the sand are removed by centrifugal force and the sand falls into a 40-ton storage bin which is kept practically full at all times. The bin is designed with a relatively small cross section and great depth to provide a greater opportunity for the sand to cool before being used again.

The sand is discharged from the bottom of the sand storage bin onto an apron conveyor which carries it to the boot of the second elevator. Here it is carried up a distance of 44 feet and discharged into a second aerator, which operates on the same principle as the first. The sand is discharged from the aerator onto a flight conveyor which carries it to the bins located over the molding stations. The return strand of the conveyor runs in a lower trough and automatically returns the excess sand to the system.

Units Are Connected

All units in the sand handling system are controlled electrically and are interconnected. In this way it is impossible to start any one part of the system and pile up sand on some other unit which is not in operation. This also applies to stopping the system. In case of a breakdown, all switches are thrown automatically.

The entire system has a capacity of approximately 100 tons, with 60 tons in the machine bins and 40 tons in storage at all times. In case of a breakdown, which as yet has not occurred, the reserve supply of 40 tons will permit the molding operations to be carried on for about 2 hours without delay. All of the labor required in caring for the sand system is performed by one man, who also does the oiling.

The preliminary engineering work was done by Edwin S. Carman Inc., Cleveland and the sand handling equipment was designed and built by the Osborn Mfg. Co., Cleveland. The gravity conveyors were supplied by the Eastern Corp., New York. The cleaning room also is equipped throughout with gravity conveyors, made by the same company, which allow castings to pass in an uninterrupted flow from the tumbling barrels and sandblast to the chippers, grinders, inspectors and the shipping platform where they are loaded.

Electrochemists Study Gray Iron

CONSIDERABLE interest in the production of high test gray iron and electric furnace gray iron developed at one of the sessions held during the three-day semiannual meeting of the American Electrochemical society at the Statler hotel, Detroit, Sept. 25 to 27. The last paper presented in the scientific session under the direction of Dr. Louis Kahlenburg, chairman, on Sept. 25, was by C. H. Morken, Detroit Electric Furnace Co., Detroit, on "The Detroit Rocking Electric Furnace as Applied to the Production of High Test Gray Iron."

Dr. Richard Moldenke, Watchung, N. J., chairman in opening the topic for discussion reviewed briefly some of the work that has been done in producing high test cast iron. The dividing line between ordinary gray iron and high test gray iron, according to Dr. Moldenke, may be placed at about 30,000 pounds per square inch tensile strength; 2500 pounds transverse breaking load with a deflection of 0.25-inch on the standard arbitration test bar. In actual production the values are considerably higher, and with alloy additions tensile strengths considerably over 50,000 pounds per square inch may be obtained.

One member inquired whether a gray iron with 60,000 pounds per square inch tensile strength would have six-sevenths of the value of a 70,000 pounds per square inch steel, and if by doubling the tensile strength of gray iron, the impact value was doubled. It was explained that steel and gray iron had widely varying characteristics which would make comparison difficult. However, one member stated that elevated temperature tests showed that at 1000 degrees Fahr. carbon steel lost 50 per cent of its strength while gray iron had lost only 15 per cent under the same conditions. Impact strength of gray iron poured in permanent molds was doubled by heat treatment.

Advises Small Charge

Dr. Moldenke believes that small charges should be used in the cupola, say 500-pound charges in a 54-inch cupola, to obtain the best results in physical properties of gray iron. One member pointed out that actual analyses of individual pigs showed a variation of as much as 2 per cent in silicon, and that to overcome the wide variation, his firm had adopted a 12,000 pound charge in the cupola. While Mr. Morken in his paper mentioned that use of a rocking electric furnace eliminated gas in gray iron, others stated that they believed if the metal was melted, properly, gases hardly will be present.

An inquiry was made on the availability of rapid methods for determining the physical properties of gray iron in continuous melting. One method used a chill test bar and a carbon determination where only one type of iron was produced. That method is being used satisfactorily in a large cast iron pipe shop. Another method was the brinell hardness value which according to the speaker gave excellent results in properties of production castings.

Speakers present indicated that gray iron with a tensile strength of approximately 60,000 pounds per square inch can be obtained consistently in the electric furnace without the use of alloys. One speaker stated that with the electric furnace gray iron with a tensile strength of 40,000 pounds per square inch was obtained regularly from all scrap mixtures. The metal was tapped around 3000 to 3100 degrees Fahr., and the furnace lining has served for 1100 heats of 2000 pounds and over, with normal patching costs.

While the electric furnace usually is considered as a batch melting unit, several pointed out that more or less continuous melting can be obtained by removing a definite quantity of the molten metal and charging in the same quantity, and allowing it to attain the proper temperature. The time interval required to bring the added metal to temperature will depend upon the furnace capacity, power available, and the amount of metal removed each time. One particular application of the electric furnace is stated to be in plants were considerable quantities of scrap raw materials are available. That material may be used to produce desired castings. Transportation problems involved in handling the scrap are said to be reduced, and the value added to the scrap when made into castings also is an important factor. One speaker stated that one plant, where considerable scrap was available, had installed an electric furnace which pays for itself every 6 months.

Preventing Unsoundness *in* Bronzes and Red Brass

Part III

COPPER-tin-zinc-lead bronzes are essentially solid solution type alloys of copper, tin and zinc with the lead distributed mechanically as a separate entity. Under ordinary conditions the alloys exhibit coring and dendrites. The copper-rich portions of the copper-tin-zinc alloy separate out first forming the pine tree-like forms shown in Fig. 17. With higher tin some delta eutectoid is formed as shown in Fig. 18. Lead is evident as black, rounded spots depicted in Fig. 19. Since those components (lead and delta eutectoid) occur in the latter part of the solidification period, they are found between the primary dendrites in the metal last to solidify.

In addition to unsoundness difficulties caused by gases, certain elements included in bronzes and red brass as unintentional or intentional additions have a considerable effect upon the properties of the alloys under discussion. For example, the bad effects of aluminum are quite well known. Vickers in his *Metals and Their Alloys* states: "Rolfe, *Engineering*, Nov. 19, 1920, found that aluminum oxidized and caused oxide films between the grains of the metal. It increased the amount of liquid contraction and according to Johnson, *Engineering*, Sept. 20. 1918, was also responsible for a greater resistance on the part of the alloy to absorption of the delta constituent on annealing. It has been the experience of many founders that a little aluminum, insufficient to show on the skin of the castings, caused marked charges in the behavior of the alloy during foundry operations. When the castings are broken off the gates when hot, the normal metal will break at that temperature with a straight fracture, tearing in neither to one side or to the other; but the aluminized metal will have a fibrous tear, and the fibers frequently reach into the casting, not like a break along the crystals, but with long silvers of fibers, which are usually colored a deep gold on the torn boundries. For sand castings aluminum is troublesome in case of gun metals; but for die castings, it has to be used with these alloys."

Properties Affected

A NUMBER of elements added intentionally or unintentionally have a considerable effect upon the properties of bronzes and red brass. Elements which have a deleterious effect include aluminum, antimony, arsenic, bismuth and iron. Nickel appears to have a beneficial effect while silicon causes incipient shrinkage. Data on the effects of those elements obtained from the work of various investigators are presented in this article. It is the third of a series on unsoundness in red metal alloys. The second appeared in the Sept. 1 issue of THE FOUNDRY.

Primrose according to F. Johnson, *Engineering*, Sept. 20, 1918 states that aluminum causes the formation of a skin on the skimmed surface of the molten metal, increased contraction and increased corrodibility (in gun metal). Guillet *Revue* de *Metallurgie*, 1910, 429, claims that a small addition of aluminum, leaving only a trace in the finished casting, enhances the mechanical properties of gun metal. Dewrance, *Bronze Founding*, May, 11, 1927, objects to aluminum on account of the excessive shrinkage produced. F. Johnson thinks that the effects of aluminum should be studied further. The possibly desirable presence of increased shrinkage is offset by the bad tendency toward tenaceous alumina scum. Bad effects of aluminum are mitigated by annealing. He holds that aluminum hardens and embrittles gun metal. Silberstein, *Metal Industry* (London) 1929, vol. 34, objects to aluminum as low as 0.001 to 0.003 per cent, claiming that even these small percentages can be detected on the surface of the alloy. He says that it causes segregation in leaded brasses and bronzes. (However, a good yellow brass is produced using 0.20 per cent aluminum and 3.0 per cent lead).

Studying the 88-6-4-2 alloy melted in a neutral atmosphere, Bolton and Weigand, the American Institute of Mining and Metallurgical Engineers, 1930, state: "Even small percentages

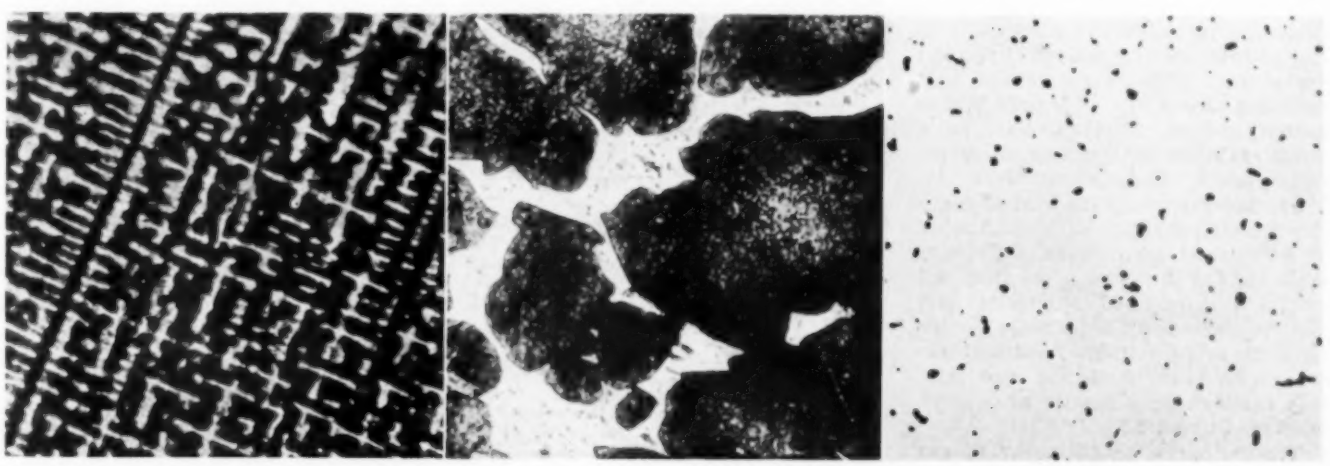


Fig. 17—*Dendrite Formation According to Weigand*, 50 *Diameters. Fig.* 18—*Delta Eutectoid in* 88-10-2 *Alloy According to Weigand*, 500 *Diameters. Fig.* 19—*Black Spots Are Lead in a* 2 *Per Cent Lead Alloy*, 100 *Diameters*

Fig. 20—Alumina Inclusions in Bronze, 1000 Diameters

of aluminum change the (skin) color of the alloy, and modify its crystallization characteristics. Larger percentages make it weak and brittle, with extremely coarse grain. The maximum percentage of aluminum in the specimens examined was 0.13 per cent. The inclusion shown Fig. 20 are incidental if interesting. The hardness is reduced from 60 to 65 to 57. As shown elsewhere the effect is not accompanied by as low specific gravity as is encountered in gassed metal." Under these conditions then most of the aluminum goes into solid solution and produces a coarse, weak, fingery structure.

Antimony Causes Trouble

Under older methods of analysis the determination of aluminum was tedious and uncertain. Analysis employing the ammonium salt of aurin tricarboxylic acid is recommended as this delicate reagent shows red coloration when even slight traces of aluminum are present.

Another element which when present, may cause trouble is antimony. Some investigational work has been carried out on the effects of antimony, and some opinions follows: H. S. Primrose claims that antimony is harmful, but, except in large castings, as much as 0.1 per cent will not cause serious embrittlement. Gulick THE FOUNDRY, 1917, states that antimony in copper-tin alloys lowers elongation and conductivity and grain size. It increases tensile and hardness. Johnson's experiments, *Engineering*, Sept. 20, 1918, made on a small scale do not confirm these results. Rolfe, *Engineering*, Nov. 19, 1920, has gone into the matter more thoroughly, dealing with a number of large sand castings on a foundry scale. Added in percentages from 0.5 to 1.5 per cent to admiralty gun metal, antimony decreased the strength and ductility. It caused unsoundness both in chilled and sand cast castings. His results are shown in Figs. 21 and 22

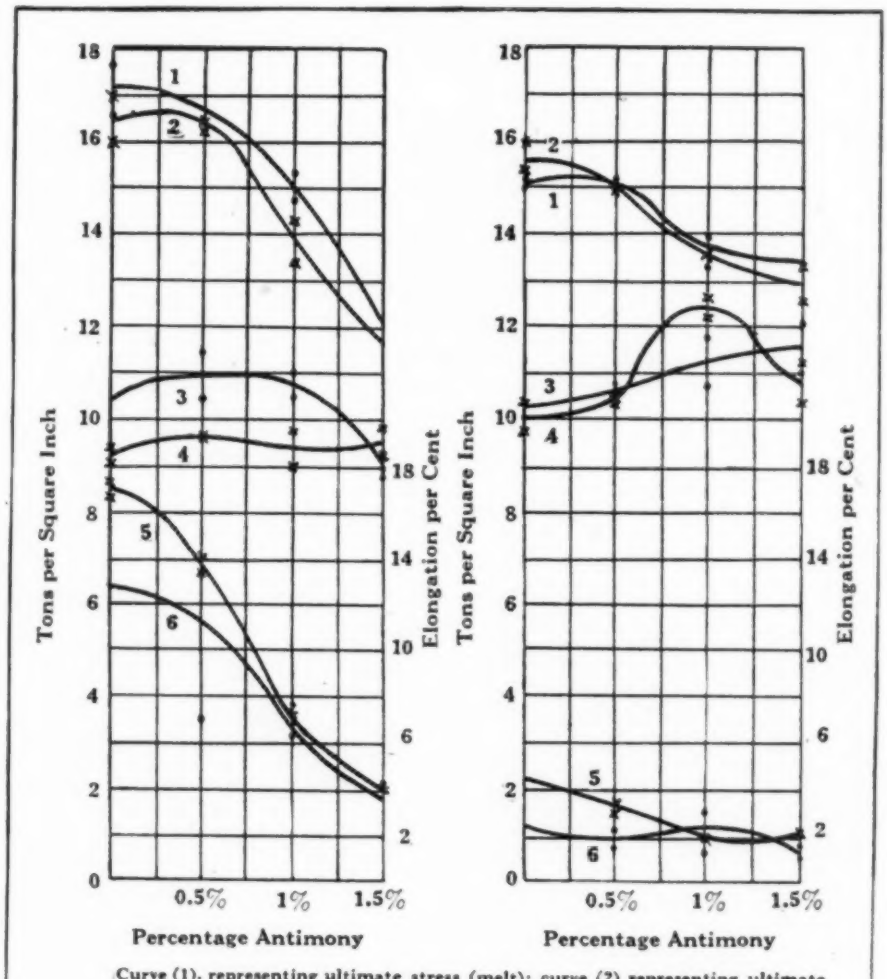
The influence of antimony in red brass was determined by Czochralski *Zeitschrift fuer Metallkunde*, 1921, as follows: Up to 0.3 per cent antimony has no deleterious effect, but larger amounts tend to make the alloy porous, hard, and brittle, which defects may be remedied partly by the addition of 2 to 5 per cent lead. The maximum tensile strength ductility, and resistance to shock in each series was obtained with 0.5 per cent antimony; higher proportions caused a rapid fall in the values obtained for these properties. Less than 3 per cent antimony cannot be detected in the microscopic structure of the alloy unless about 5 per cent lead also is present, when dark segregated patches are seen unevenly distributed throughout the ground mass.

Antimony is found in poorer grades of tin, and in improperly selected composition ingot. In the latter case it comes in through the lead-tin-antimony alloys and other types of white metals, particularly bearings, found in miscellaneous scrap. Antimony contamination is avoided easily by careful selection of melting stock.

Other elements having a detrimental effect on bronzes and red brass are arsenic, bismuth and iron.

Rolfe, *Engineering*, Nov. 19, 1929, indicates that over 0.3 per cent arsenic in gunmetal makes the metal brittle. Primrose objects to presence of arsenic. On the other hand Johnson and Murray claim that up to 0.3 per cent it is beneficial, increasing the elongation and soundness. Later Rolfe suggests limiting arsenic in gun metal to 0.4 per cent. Arsenic is obtained in some brands of copper. Even a small amount of bismuth is said to be detrimental, separating out as a brittle intercrystalline constituent. It is not a common contaminant, the main source being the various fusible alloys etc.

Small amounts of iron apparently cause little if any trouble. Large amounts, increase the hardness strength and brittleness, and cause intensely hard spots, as shown in Fig. 23. Excess iron may be incorporated through scrap borings, and through stirring with iron rods. It is reduced easily to a low point in the manufacture of composition ingot. Gulick, THE FOUNDRY 1917, states that manganese acts as a deoxidizer and increases the soundness, strength and toughness of bronze castings,



Curve (1), representing ultimate stress (melt); curve (2) representing ultimate stress (re-melt); curve (3) representing yield point (melt); curve (4) representing yield point (re-melt); curve (5) representing elongation (re-melt); curve (6) representing elongation (melt).

Fig. 21—(Left)—Sand Cast Gun Metal Containing Antimony. Fig. 22—(Right) —Chill Cast Gun Metal Containing Antimony

Table I

Effect of Silicon in Bronze

Silicon Per cent	Tensile strength lb. per sq. in.	Elongation per cent	Elastic limit lb. per sq. in.	Pouring temp. deg. Fahr.
0.07	42,410 43,370	40.4 53.3	17,750 17,180	2,180
0.29	38,810 38,450	20.0 19.3	19,500 19,550	2,200

Table II

Complete Analysis Log

Sulphur Per cent	Copper Per cent	Tin Per cent	Zinc Per cent	Lead Per cent	Brinell Number
0.046	87.20	5.56	5.03	1.87	65
0.068	88.42	6.08	3.10	2.04	61
0.140	87.48	5.83	4.79	1.56	62
0.231	88.38	5.67	3.58	1.94	63

while reducing the elongation slightly. Manganese is not a likely contaminant in bronze and red brass.

Addition of small amounts of nickel, up to 1.0 per cent are not detrimental to the soundness or strength of bronze. A recent investigation is that by Milligan and Weigand (*Thesis*, University of Cincinnati 1929). These workers find that up to 1 per cent nickel, when substituted for tin, improves the physical properties somewhat at room temperature, and the strength of the alloy at elevated temperatures (700 degrees Fahr.) was increased slightly up to 2½ per cent. Greater amounts (up to 5 per cent in the alloy examined apparently reduce the strength. When from 3 to 5 per cent nickel is substituted for 3 to 5 per cent tin, the coring effect is not so pronounced. The alloy assumes a polygonal network structure rather than the dendritic formation. Brinell hardness is reduced on all nickel substitutions, from 0.5 to 5.0 per cent, and elongation is increased up to 1.0 per cent nickel substitution. With over 3 per cent nickel there was increased difficulty in casting the alloy, and blowholes increased. Nickel as an impurity is unlikely to cause any trouble in bronzes and red brasses. In all probability, amounts up to 1 per cent are beneficial rather than otherwise.

Use of silicon as a deoxidizer for cast copper is an old process. However, Guillet showed that a small amount of silicon is slightly detrimental to the properties of a bronze containing 89 per cent copper, 9 per cent tin, 1.5 per cent zinc, and 0.5 per cent lead. Thews, THE FOUNDRY 1928 objects to use of silicon in lead alloys. He gives no quantitative data. Bamford and Ballard, *Journal*, Institute of Metals (London) 1920, also state that silicon is not a suitable deoxidizer for alloys containing lead, since lead silicate is formed and dross results. (It is obvious that oxide must be present to cause trouble from this source).

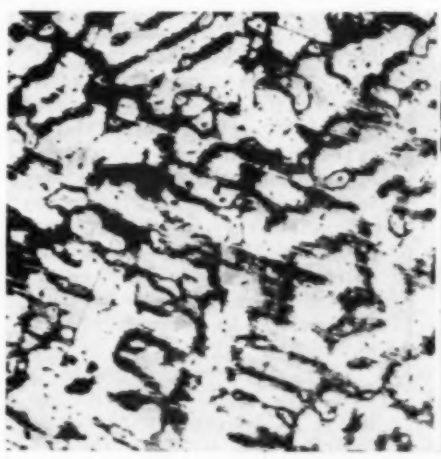
St. John, Eggleston and Rynalski, American Institute of Mining and Metallurgical Engineers, 1930, say that small percentages of silicon in foundry brasses and bronzes containing copper, tin, lead and zinc (when melted in an indirect arc furnace) have a tendency to produce a coarse dendritic structure with intercrystalline fissures, which causes castings made from such metal to be weak and porous. They go on to say: "Alloys of copper with zinc or tin or zinc and tin, in the proportion described in this paper, but containing no lead, are hardened and strengthened by the addition of small percentages of silicon. There is no apparent detrimental effect on the structure of the metal."

The previously mentioned authors indicate that casting at low temperatures and chill casting conteracts the effects of silicon. The addition of nickel (1 to 3 per cent) also obscures the effect. At 3 per cent nickel an alloy containing 79.5 per cent copper, 2.5 per cent tin, 8 per cent zinc, and 10 per cent lead, will preserve a fine grained structure with as much as 0.05 per cent silicon-whereas 0.03 per cent silicon is detrimental to the alloy without the nickel addition. To eliminate silicon they suggest: "The use of an alkali sulphate such as anhydrous sodium sulphate or an alkali earth sulphate, such as barium sulphate, as a flux in the electric furnace tends to eliminate the silicon by selective oxidation without appreciably affecting the normal constituents of the alloy."

St. John, Eggleston and Rynalski also mention that silicon contamination can be prevented or eliminated by use of an oxidizing atmosphere, and close their summary with: "The authors believe that silicon tends either to obstruct the formation of crystal nuclei in the molten metal or to prolong the period during which part of the metal is molten after it enters the mold. In this way a few crystals grow to large size and the shrinkage of these crystals results in openings or intercrystalline fissures: Incipient shrinkage is probably as good a term an any for this phenomenon. Anything that tends to shorten the freezing time, such as chill-casting, tends to offset the influence of the silicon. The addition of another constituent, such as nickel, which tends to form more nuclei, also tends to prevent the detrimental effect of the silicon."

The work carried out by St. John and his co-workers presumably was done under reducing atmospheres, as it was conducted in a small, indirect-arc furnace. Owing to the small size of the furnace (½-pound melts) no test bars were cast and conclusions were drawn from inspection of fractures and micrographs.

Bolton and Weigand, American Institute of Mining and Metallurgical Engineers, 1930, ran some experiments operating under neutral atmospheres. Their results and conclusions based on the alloy 88-6-4-2, which normally runs 42,000 pounds per square inch average tensile are as follows: "In the previous paper, American Institute of Mining and Metallurgical Enginers, 1929 the authors showed that the bronze studied at that time was substantially free from silicon, containing only about 0.006 per cent. Silicon was added up to 0.03 per cent. No changes in the characteristics of the alloy were noted. Then the effect of



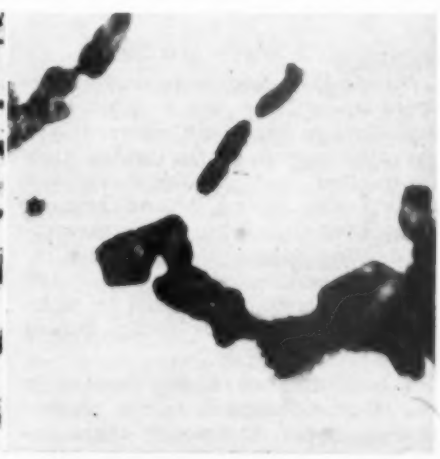


Fig. 23—Hard Spots in Bronze Due to Iron. Alloy Practically Unmachinable, 100 Diameters. Fig. 24—Inclusions in Bronze Containing 0.23 Per Cent Sulphur, 1000 Diameters

Table III

Effect of Sulphur in Bronze

Sulphur Per cent	Tensile strength lb. per sq. in.	Elongation per cent	Elastic limit lb. per sq. in.	Pouring temp. deg. Fahr.
0.046	{ 35,000 { 35,410	24.8 25.6	16,300 { 16,600 }	2,200
0.068	{ 38,140 { 36,820	31.9 28.0	16,440 { 16,420 }	2,180
0.14	{ 38,600 { 39,430	34.7 38.1	16,970 { 16,590 }	2,150
0.231	{ 37,660 { 36,010	26.0 28.0	16,810 { 16,590 }	2,150

0.07 per cent silicon in the finished alloy was examined. In spite of slight porosity, the physical properties are as shown in Table I. The fracture looked good, and tendency toward dendritism was negligible. The outside of the casting had a distinct silver-like tinge. With 0.29 per cent silicon in the finished alloy the physical properties were as shown in Table I. The drop in elongation is pronounced. Elongation is much lower than that obtained in tht regular alloy. Brinell hardness is 74, which is high for this alloy.

"The fracture was close grained on the edge but was lemon yellow and open grained, that is dendritic, in the center of the section. Pouring temperature was 2200 degrees Fahr. and the metal poured clear and fluid. The exteriors of the castings were covered with thin white films and there was complete absence of bronze color. Tops of risers were blackened and smooth appearing.

"Higher magnification shows no inclusions or new components that might be considered typical and due to silicon. Silicon evidently goes into solid solution in the alloy. The authors believe that it exerts a deleterious effect by changing either the contractive or fluidity properties or both. In larger percentages it raises the elastic limit and maintains tensile strength even though the center of the bar is quite porous. In the authors' opinions 0.50 per cent silicon or over is likely to prove dangerous in plant practice."

Silicon therefore, is an unwelcome contaminent, and has a most serious effect in high lead alloys. It apparently causes coarse grain, high contraction, and possibly lengthens the freezing range. Silicon bronzes and silicon-copper are the usual contaminating agents. Under highly reducing conditions silicon is oxidized easily, and may be removed by melting in a slightly oxidizing atmosphere.

Literature abounds in reference to the effects of sulphur on the properties of copper. Conversely there appears a paucity of quantitative data on the effects of sulphur in cast bronzes and red brasses. However, Bolton and Weigand state: "With sufficient sulphur to produce 0.046 per cent, sulphur in the finished alloy physical properties were as shown in Table III. Behavior of metal in handling and appearance in castings was like regular bronze. The fracture was fair and the analysis is too high in zinc as shown in Table II. With 0.068 per cent sulphur physical properties were as shown in Table III. Fracture was fair, with a tendency toward looseness. With this percentage of sulphur the castings had a greenish tinge on the skin, although no peculiarities were noted in the molten metal. A third component shows up faintly on the polished sample, among the darker spots due to lead and porosity.

"With 0.15 per cent sulphur physical properties were as shown in Table III. The molten metal appeared to be slightly sluggish. The castings had a faint tendency toward greenish tinge. Fracture of test bars appeared good. The machined and pulled bars had a peculiar appearance. As on any ductile alloy, stretching caused a ribbed grain appearance; on these bars one side showed small grains, the other showed coarse grains.

"Additions of lump sulphur were made to experimental heats. The percentages of impurity reported are those determined by analysis in the finished alloy. Fig. 24 shows a typical inclusion magnified 100 diameters. The inclusions were blue gray or slate color. When the sulphur was increased to 0.231 per cent the physical properties were as shown in Table III. No peculiarities were noted in the molten metal. According to these tests the effects of sulphur are not marked, but it seems dubious practice to maintain this impurity over 0.05 per cent if best results are desired."

Summarizing the effect of sulphur it would appear that under some melting conditions the sulphur forms sulphides and inclusions in the metal. It apparently is not radical in its action. Sulphur may be obtained from the fuel, and from high sulphur copper, or high sulphur composition ingot. Also it is obtained in considerable amounts when barium sulphate is used as a flux. By the use of soda ash fluxes it may be found possible to reduce sulphur content.

4000 Years Ago

AN ITALIAN expedition, which is at present engaged in searching for traces of prehistoric man near Livingstone, Rhodesia (southern Africa), reports that it has made a most unusual discovery in the form of an ancient iron foundry, according to a dispatch received in the department of commerce from Assistant Trade Commissioner DuWayne G. Clark, Johannesburg. The site of the foundry is said to have been buried some six feet deep in an enormous cavern in strata of palaeolithic age.

Here, some 3000 to 4000 years ago, it would seem some race of superior intellect smelted iron by primitive methods not unlike those known to the present South African Bantu people. The skeletons of men, it is said, prove that the early knowledge of smelting came to Africa during the time of the Bushmen, approximately at the earliest phase of their late stone age culture, the foundry being superimposed directly on a stratum bearing Moustierian implements.

This discovery, which is unique in the history of archaeology, is believed to throw an entirely new light on the history of metallurgy, especially in South Africa.

Chicago Founder Dies

Henry Lindahl, 71, president and founder of the Henry Lindahl Foundry & Machine Co., Chicago, died Sept. 30. He had been active in the affairs of the company until the day before his death. He was born in Sweden and came to this country when he was 11 years old, settling with his parents at Sycamore, Ill. He organized the Lindahl company in 1895.

Adds Six New Members

The following foundries recently have become affiliated with the Gray Iron institute, Terminal Tower building, Cleveland, according to an announcement by Arthur J. Tuscany, manager: Philbrick-Booth & Spencer Inc., Hartford, Conn.; Greenlee Foundry Co., Chicago, Fremont Castings Co., Worcester, Mass.; R. P. Power Foundry Co., Worcester, Mass.; Titus Foundry, Coldwater, Mich.; Peerless Foundry Co., Cincinnati.

Questions & Answers on FOUNDRY PRACTICE

GENERAL

Iron Molds Expand

QUESTION

Some time ago I read in THE FOUNDRY a question and answer under the heading "Uses Permanent Molds" and dealing with the subject of casting hard iron balls. I should like to have further particulars, for example: Are the molds coated with any refractory material, what is the approximate life of a mold, what is the approximate rate of production on 1-inch balls, and what form of clamp is employed to hold the halves of the mold together? I have tried a mold of this kind, but find that the halves spring during the pouring operation with resulting fins at the joint line of the castings.

ANSWER

The basic principle on which all permanent molds operate is resistance to expansion and distortion. No form or method of clamping will hold two or more parts of a metal mold in place if they are subjected to a temperature that will cause them to buckle or spring. Makers of ball molds have recognized this principle and as a result the molds are massive castings which absorb the heat from the comparatively light balls without distortion. This principle—so far as printed records show—first was discovered and applied by E. A. Custer in a foundry which he operated for several years at Tacony, Pa., and where he made thousands of tons of gray iron castings in iron molds.

Taking the questions in the order presented the molds are not coated with any refractory material, but are swabbed with oil before each cast. No statistics are available on the life of the molds. At one plant in the west the same set of ball molds has been in daily operation over a period of several years. Apparently they will last indefinitely. The rate of casting production will depend on the number of mold cavities in the iron blocks, the facilities for pouring the iron, and the number of molds in the battery. The mold halves are not clamped in the ordinary sense. One half is mounted rigidly on a foundation. The second half is moved back and forth by a hydraulic plunger. In some of the earlier installations the second half was moved on slides by a lever and toggle arrangement. Compressed air may be applied.

THIS department covers all problems relating to metallurgical, melting and molding practice encountered in making steel, malleable-iron and gray-iron castings. Questions submitted by bonafide subscribers to this department will be answered by members of the editorial staff of The Foundry, supplemented where occasion requires by the advisory staff whose personnel is as follows:

John H. Hall
Cast Steel

H. A. Schwartz
Malleable Cast Iron

J. W. Bolton
Gray Cast Iron

All questions should be addressed to the Editor, The Foundry, Penton Building, Cleveland.

Q & A

Steel Increases Density

QUESTION

We are considering the use of a certain amount of steel scrap in our stove plate mixtures, but before making any change we shall appreciate your opinion on what advantages we may expect from this practice.

ANSWER

Steel is added to gray iron mixtures primarily to increase the strength and density of the resulting metal. Where these factors are not important, steel scrap is employed as a measure of economy. In recent years the gap has been closing, but formerly quite a wide differential existed between the prices of steel and cast iron scrap. In some plants a considerable quantity of steel scrap is produced as a by product of operation. Naturally this material may be utilized to advantage as compared with pig iron or gray iron scrap bought in the open market. Density and strength are desirable features in practically all castings, but they are not absolutely essential in stove castings. This is only another way of saying that ordinary gray iron mixtures are perfectly satisfactory. Many stove plate foundries employ steel scrap in their mixtures where they find they can reduce the cost. Naturally the other component parts of the charge must be adjusted to compensate for lack of silicon in the steel.

Q & A

Blower Is Too Large

QUESTION

Apparently the fan for our 30-inch cupola is too large. I find that it has been boxed in on both sides with the exception of a slit about 4 inches wide through which the air is drawn. The fan is driven by a direct connected 25-horsepower motor running at 1750 revolutions per minute.

ANSWER

Probably some good reason exists for the presence of a blowing outfit so manifestly out of place on a 30-inch cupola. The cupola originally may have been lined to a large size, or, the owner may contemplate enlarging it later. In the meantime the boxed-in arrangement serves to cut down the amount of air going into the cupola. However, the arrangement is extravagant and represents a waste of power. A 25-horsepower motor is too large for a 30-inch cupola.

Several alternative methods suggest themselves, but the adoption of any one in preference to others depends on local conditions. In fact a careful survey of the situation may satisfy you that the present arrangement, while not ideal, may have to be endured temporarily. You might install a smaller motor. You might disconnect the present motor and make

a new layout with the fan driven from a jack shaft. The relative size of the pulleys could be changed to give you any desired speed on the fan. A 30-inch cupola should melt about 3 tons of iron per hour with a consumption of approximately 100,000 cubic feet of air in the same period. This is at the rate of 1666 cubic feet per minute. With this data for a foundation you can figure the necessary capacity of blower and motor to deliver the air at about 8 ounces pressure. Before making any change we suggest you write the blower manufacturer for advice and suggestions. All the prominent makers of blowing equipment have prepared extensive directions in the form of tables and other literature and will be glad to forward them upon request. The same is true of the cupola manufacturers. They will tell you how to operate the cupola to the best advantage.

Q & A

Iron Blows from Rods

QUESTION

We are having trouble with a reinforced white iron crusher jaw 16 x 24 inches, 3 inches thick at one end and 4½ inches thick at the other end. We place six ⅜-inch steel rods in each mold, four longitudinally and two across. Apparently these rods cause a commotion in the iron and the result is a collection of blowholes that condemns the casting.

ANSWER

Unless the rods are dry, perfectly clean and free from even the trace of an oxide scale, they will cause a commotion in the molten iron. Various methods from pickling to sandblasting are available for cleaning the rods. The method adopted in any particular place depends on local conditions and equipment. You might polish them in a tumbling barrel. After the rods have been cleaned they must be covered with oil or some other material that will prevent an oxide film from forming on the surface. Any kind of oil will answer the purpose. Some foundrymen prefer to paint metal inserts with red lead, tar, pitch, or yellow shellac as prepared for use in the pattern shop. Where the rods are perfectly clean and dry the metal will lie against them quietly.

Q & A

Vises Show Defects

QUESTION

We are having trouble with some of our vise castings and will appreciate your advice on how to secure better castings. Kindly supply data on grade of sand, iron mixture, how to fuse the iron to the steel face, and the proper time to shake out the casting.

ANSWER

Character of the sand, the iron, and shaking out time are not factors of major importance in this class of castings. Sand that has been found suitable for other castings of similar size and weight will make satisfactory vise molds. Iron that machines readily in castings of a similar section will machine just as readily in a vise casting if proper precautions are observed. The steel face plate is responsible for all or nearly all rejected castings of this kind. In some instances an oxide coating on the plate creates gas pockets in the casings. In other instances the metal does not fuse properly and as a result the plate works loose. In still other instances the first wash of molten metal remains on the plate in a chilled condition and as a result it is too hard to machine, particularly along the edges. All these troubles may be prevented by: (1) Grinding the plates perfectly bright and then covering the surface with any material that will preserve the surface from the oxygen in the air. A thin coat of shellac is as good as any. Some foundrymen prefer to coat the plate with tin. (2) Arrange the mold in such a position that a stream of iron flows over and past the face of the plate until the plate is raised to a white heat. The outlet then is plugged and the mold is allowed to fill from the stream that never has ceased. On large jobs a pocket or cavity is formed in the sand at the back of the plate. The plate first is heated with a stream of iron on this side, before the iron is allowed to enter the mold proper. As a final precaution it is advisable to run some iron through the riser to carry off any gas that may have developed. This is one of the cases where convenience in making the mold must be subordinated to convenience in pouring the mold with the plate in a certain position.

GRAY IRON

Air Furnace Is Used

QUESTION

Have you any data on the uses, physical properties and chemical composition of a metal known as gun iron?

ANSWER

Gun iron refers specifically to the iron that was melted in air furnaces and cast into cannon before the advent of the modern steel cannon. The preferable term now is air furnace iron. That metal or alloy is gray cast iron which has been melted in the air furnace. The process is similar to melting iron for malleable practice, but differs in that the molten metal tapped from the furnace gives a gray fracture instead of white fracture of hard malleable iron.

Air furnace iron is used particularly in foundries engaged in producing chill-cast and sand-cast rolls. It also is used for casting gas and steam engine cylinders and liners, piston rings, brake drums, etc., in some foundries where air furnaces are available. The composition of air furnace iron is varied to suit the specific castings made. An average range may be given as: Silicon, 1.0 to 1.5 per cent; sulphur, 0.06 per cent; manganese, 0.50 to 0.60 per cent; phosphorus, under 0.30 per cent, and total carbon, 3.0 to 3.25 per cent.

The iron is said to be extremely tough and dense, and not hard to machine even though the silicon is considerably lower than that cast from a cupola for the same type of casting. It recently was stated that a tensile strength of 50,000 pounds per square inch was obtained from a straight pig and scrap mixture melted in an air furnace. Steel additions to the charge mixture undoubtedly will increase the strength.

Q & A

Iron Is Soft

QUESTION

We manufacture electrical equipment, and would like some information on the composition for gray iron caps or end housings for motors. One of the caps is 4 3/8 inches in diameter and weighs about 7 pounds and the other is 7 5/16 inches in diameter and weighs about 1 1/2 pounds. The iron used in making up the castings has the following analysis; Silicon, 2.73 per cent; phosphorus, 0.567 per cent; manganese, 0.562 per cent; sulphur, 0.066 per cent; graphitic carbon, 3.19 per cent and combined carbon, 0.36 per cent. We get good castings but we want to improve the quality of our product, especially in surface and machining. Will the addition of nickel give us better results or can you suggest a better mixture for the purpose using nickel? Should the nickel be added to the charge or in the ladle, or are both methods comparable?

ANSWER

In our opinion it would be difficult to increase the softness of castings of the analysis given. The metal should be quite soft with that composition. Slightly greater softness could be obtained by dead annealing at 1500 degrees Fahr. However, it is doubtful whether that would pay. The addition of nickel to an iron of that composition would not improve its machinability, except possibly in the extremely thin sections, and would not make it softer.

It seems probable that with the heavier cap especially, you may have a rather open grain which does not promote the smoothest type of surface unless special finishing cuts are employed. Also that type of metal is quite subject to shrinkage unless melted extremely hot and good feeding is provided. Such shrinkage spots sometimes resemble localized, extreme open grain—and since such castings have soft spots, might result in tool chatter and consequent difficulty in machining.

The metal you use is what metallographists call hypereutectic; its sum of carbon plus 0.3 times the silicon is over 4.2 per cent. Such metal usually is quite weak. Improvement in strength and finish can be obtained

by adding a small percentage of steel scrap (5 to 10 per cent) in the cupola, melting hot and not using too much coke. For many conditions a 10 to 1 ratio of coke between charges is plenty and it is rare that an 8 to 1 ratio will be needed. Your analysis indicates a high percentage of pig iron because of the low sulphur. A little more scrap will help close the grain. These suggestions will assist in producing a stronger, closer grain iron—and with careful control and study, it is possible to make better iron of equal or slightly better machinability than the coarser grain iron. The carbon in the iron should not be over 3.45 per cent and the silicon should range from 2.50 to 2.75 per cent.

If you wish to use nickel, the silicon should be reduced to 2.25 to 2.50 per cent and 0.50 to 0.75 per cent nickel substituted for the silicon eliminated. The nickel in the form of shot may be added to the ladle. There should be no difficulty from segregation if the iron is hot. Nickel also may be added in the cupola. In either case do not forget to allow for the nickel in the foundry return scrap in all heats after the first.

STEEL

Operates Converter

QUESTION

We have been experimenting with a small side-blown converter shown in the accompanying sketch with little success. The interior of the converter is raised to a dull red with an oil torch and then 250 pounds of white-hot iron is poured in. The blast pressure is about 3 pounds per square inch. After about 15 minutes a hard slag forms over the surface of the iron and we have to dump the converter to prevent freezing of the metal. No flame appears at the mouth of the converter, only a shower of sparks which gradually decreases in volume and brilliancy.

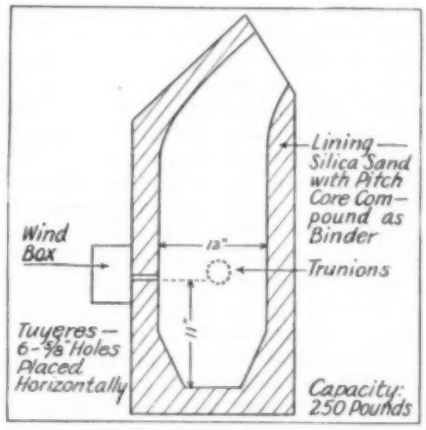
We have been using regular cupola iron containing 2.25 per cent silicon for our experiments. There seems to be an excessive amount of fine shot thrown out by the converter during the blow perhaps 10 or 12 pounds. A layer of iron about an inch thick also forms on the entire lining above the molten metal. We have tried varying the height of the iron in the converter as well as tilting it at various angles without results. You will note from the sketch that the hood or opening of the converter is reversed from usual practice, but we cannot see where that should make any difference in the operation or in the results obtained.

ANSWER

We can see no reason why the change in the direction of the nose of the converter should make any difference in its operation. It seems rather doubtful whether so small a charge as 250 pounds can be blown successfully and poured unless only a few castings are to be made from each blow. Naturally, to keep so small a quantity of steel hot enough to pour many small castings is quite difficult.

The use of regular foundry cupola iron is not practicable as phosphorus for steel must be kept below 0.10 per cent and preferably below 0.06 per cent. The phosphorus in most foundry iron is so high that steel made from it would be exceedingly brittle. This of course, should not have any influence on the operation of the converter, though it will have a fatal influence upon the metal produced. The metal charged into the converter should contain about 2 per cent silicon with manganese below 1 per cent preferably below 0.75 per cent, with phosphorus and sulphur about 0.05 to 0.06 per cent. Manganese above 1 per cent interferes with the operation of a side-blown converter, leading to serious slopping of the metal.

The fact that no flame appears at



Nose Turns Opposite Way

the mouth of the converter indicates that the blowing is not conducted properly. The vessel should be filled to such a height that, when the top of the metal is just level with the tuyeres, the vessel is tilted forward about 7 to 8 degrees. In other words the converter is filled so full that were it turned into a vertical position, the metal would run into the tuyeres. This can be observed by looking through the tuyeres from the back, and turning the vessel until the metal just reaches the front of the tuyeres. For this purpose it is absolutely necessary that the windbox have a removable cover or a large opening. The opening is also necessary at times so that the tuyeres may be punched out with a bar when they get choked with slag, which may happen frequently.

When the blast is turned on, the vessel should be tipped forward about 10 degrees, which will bring the level of the metal a little below the tuyere openings and will make the level of the metal such that the blast will strike it at the middle of the converter. During the first few minutes blowing, only sparks will come from the converter, but within 5 minutes, a flame should appear at the mouth. The converter then can be brought 1 or 2 degrees nearer the vertical which should assist in bringing up the full flame. The flame should continue until the blow is completed as described for example on pages 111 to 117 of *The Steel Foundry*, by Hall, and in other books on converter practice. Should the flame disappear, it generally means that the level of the metal in the converter has fallen to low due to slopping and other loss of metal. More metal will have to be added to bring the level back to the proper point before resuming the blow. The proper amount will have to be determined by experiment.

The description of the troubles encountered in operating this small converter strongly suggests that a blast pressure of 3 pounds is too high for so small a converter and it is suggested that it be cut down to 1½ to 2 pounds. In any event, if a proper flame is secured, the blast pressure will have to be reduced materially at intervals when the converter *boils* with a long lively flame. At that stage of the blow it is absolutely necessary to cut the blast down, otherwise large amounts of metal will be thrown out of the converter.

MALLEABLE

Strength Not in Skin

QUESTION

Certain engineers claim that by machining off the outside skin of a malleable casting the best portion of the casting is lost. Also that the core of the casting or that part under the skin does not have a tensile strength equal to the skin. Are there any authoritative articles on the subject, and what is your opinion?

ANSWER

First, we suggest that you examine, "Effect of Machining and of Cross Section on the Tensile Properties of Malleable Cast Iron" included in Vol. XX, Part II, 1920, *Proceedings* of the American Society for Testing Materials. That article shows that the decarburized surface is but little stronger though somewhat more ductile than the center. Also let the engineer consider the following: The area of the standard specimen used in obtaining the physical properties of malleable cast iron is substantially 0.3 square inches. At 50,000 pounds per square inch stress, the section is subjected to a breaking load of 15,000 pounds. The circumference of the specimen is practically 2 inches and the decarburized zone is perhaps 0.04-inch thick. Consequently, the area of the decarburized zone is 0.08-square inch. If all the strength is in that zone, its tensile strength must be 15,000÷0.08 or 187,500 pounds per square inch. Is that consistent with the fact that the skin is approximately pure iron? Consider also that the largest consumer of malleable cast iron is the automotive industry whose castings are practically all machined. The idea propounded by the engineer is survival from the white heart malleable cast iron industry.

Problems in Nonferrous Founding

By Charles Vickers

Describes Copper Grades

Can you tell us briefly the difference between electrolytic copper and lake copper? Also what is the difference between casting coppr and the first two?

Lake copper is that made from the copper ores native to the Michigan copper district. It may be fire or electroytically refined and contains 99.90 per cent copper. Electrolytic copper is that refined by the electrolytic method from blister, black or lake copper although the latter generally is referred to as lake copper to distinguish it from copper from other districts. Electrolytic copper contains 99.90 per cent copper. Casting copper contains from 98.5 to 99.8 per cent copper and may consist of furnace-refined, converter bar or black copper from smelters whose ores carry insufficient gold or silver to pay for electrolytic refining; by-product copper not up to grade, or copper produced by melting up scrap.

Q & A

Copper Wire Is Hard

In our foundry we use scrap trolley wire at various times, but without the success we think we ought to get. We have noted that the new trolley wire is soft, and the used trolley wire is hard and difficult to bend. Can you tell us the reason for this difference between the two. Our furnaces are of the oil-fired tilting type of 800 to 2000 pounds capacity. One of the articles we read mentioned the use of hard wood blocks when using a crucible to melt trolley wire. Would the same apply in a noncrucible furnace such as we operate?

Possibly the new trolley wire that is soft has been annealed by fire before it became scrap. Simply heat it to a dull red and allow it to cool. Hard drawn wire is springy and cannot be pressed or pounded together to conserve space. The difference in regard to hardness or softness we believe is merely one of mechanical condition. Sometimes trolley wire is alloyed with a small percentage of tin, but this is rather an advantage than otherwise when it is used for making alloys such as red brass. The passage of the electric current through copper wire makes no change in the wire and when melted the result is just the same as with any grade of copper.

The use of blocks of wood to make charcoal for a covering is useful in crucible melting. The best manner of melting trolley wire in crucibles is in a natural draft crucible furnace deep enough to permit the use of a *deepener* on top of the crucible. The wire in lengths that when stood on end will reach to the top of the deepener can be packed in the crucible so that all the copper comprising the charge is put in cold. Then a couple wood blocks put on top, burn and give off gases that protect the projecting copper until it sinks down. The blocks become charcoal which cover the liquid surface. In an oil-fired noncrucible furnace, the wood as it became charcoal would be blown out of the furnace through the opening in the cover, and so be a waste of material.

To melt trolley wire in a noncrucible furnace, chop the wire into short lengths and charge it first, and on top place more massive material. On this place the usual flux, which may be simply glass. Then melt quickly and get the metal hot. Use enough flux to give a thin slag on the surface of the molten metal. Under no circumstances attempt to melt in this type of furnace without using some such covering.

Q & A

Makes Babbitt Metals

We are installing a furnace formerly used for melting type metal and we are planning to make babbitt metals on a commercial scale. Our raw material will be scrap babbitt. What are the best mixtures that can be made from such scrap babbitt, and also the best flux to remove the impurities?

The first thing to get is a representive analysis of the babbitt. It would be advisable to assort the various babbitts, as there are numerous kinds; some have a tin base, others a lead base, and still others may contain large amounts of zinc. They must not be melted together and the ones containing zinc, usually known as white brass are objectionable when mixed in with the nonzinc babbitts. They can be detected by melting a small portion in a hot fire when the zinc containing babbitts will emit a dense white smoke.

It will not be difficult to separate the lead base from the tin base babbitts as the color is different. When the separation has been made melt about 100 pounds of each alloy separately, and selecting a number of ingots secure drillings for analysis. In that manner there will be two analyses; one of the tin base babbitt, and another of the lead base babbitt. In the case of the tin base babbitt work to an analysis of around 8 per cent antimony; 3½ per cent copper, remainder, tin, and call it genuine babbitt. With the lead base babbitt work to 80 per cent lead 15 per cent antimony, and 5 per cent tin. A good flux to use for both babbitts is common rosin.

Q & A

Iron Inserts Blow

We are making a quantity of brass handles which contain a cast-in set screw about ¼-inch in diameter and 1-inch long. The handles are molded from a gate of 12 patterns. We lose about 35 per cent of the castings through blows. It is impractical to warm the inserts as they would chill and acquire dampness between heats. Is there any coating we can put on the screws?

It is our belief that the remaining 65 per cent of the castings will contain blows if they are cut open because the sample set screw sent to us is covered with scale. Sandblast the scale from the set screws or get a new supply of perfectly clean ones. See that only bright, clean screws are used. Copper plating the screws will prevent rusting.

Leave your molds open until just before pouring. Apply the torch for a few minutes until you are sure that any moisture collecting on the screws is driven off. Then close the mold and pour. If the screws were copper plated, the molds probably could be closed as usual and poured without any blown castings resulting.

There are all manner of coatings which are employed to cover inserts and they include linseed and other oils, shellac, rosin, smoking, etc. However, if the insert is not clean when the coating is applied blows will occur. Blows also will result if the insert is colder than the sand as the moisture from the sand collects on the colder object which in this case is the insert.

Men and Machines

Must Fit the Needs of the Particular Shop

BY ALBERT WALTON

PRODUCTION of molten metal is the first real operation in any foundry. This may be accomplished in the cupola, air furnace, open hearth or electric furnace, and in each case foundrymen are confronted with many problems peculiar to the particular type of melting practice. However, they have ample opportunity to learn from their own experience and from that of others, valuable points regarding the operation of melting units. Factors influencing profitable operation include correct purchasing; charging of metal in the proper proportions to give the quality desired; conservation of fuel in melting; positive control of melting temperatures and instruction of melters and men in charge of pouring operations as to proper pouring temperatures.

Equipment Is Necessary

Mechanical equipment is valuable for handling raw materials, molds, ladles, etc. Unloading and conveying equipment should be installed for handling pig iron, scrap, coke, sand and all other bulk commodities. Preparation of charges for cupolas or other furnaces should be done mechanically. The best arrangement for pouring metal in molds, type and size of ladles and pouring system should be utilized. Sand preparation and distribution apparatus should be used to maintain the required grain size, bond, permeability and strength, and to distribute sand to molding stations economically. In dry sand work, ovens should be installed that meet all requirements as to dehydrating temperature and fuel economy.

In steel foundries where the bulk of the product has to be annealed, properly constructed annealing furnaces with modern methods of charging and firing are of paramount importance. Chipping and cleaning operations must be governed by type and size of castings made. While each foundry's problem differs from that of others, mechanical methods are available that reduce cost and are applicable to each class of foundry. Lack of necessary handling facilitites is one of the principal causes of high cost in a foundry. Whether the buildings and general physical layout are good or poor, handling facilities can be introduced that will increase profits.

In steel foundries, to a greater degree than in iron foundries, the possibility of wasting fuel requires constant attention. Natural gas, fuel oil, coke, producer gas, etc., unless properly controlled may easily cost more than is necessary. Open-hearth furnaces, drying ovens and annealing furnaces should be scrutinized to see that the fuel used is not being wasted and that the temperature most effective for the particular operation is being obtained.

Lowers Costs

CORRECT technique is not the only factor effecting successful foundry operations. While melting, molding and core making are the important operations, the selection of competent supervisors; co-operation between the engineering, patternmaking and foundry departments in the construction of patterns and design of castings; installation of mechanical equipment; etc., all have a direct bearing on the final cost of product. Those factors are discussed in this article which is abstracted from a paper presented at a meeting of the Pittsburgh Foundrymen's association last spring. The author is consulting engineer, United Engineering & Foundry Co., Pittsburgh.

Competent supervision is necessary to be sure that employes are working efficiently and that waste does not occur within the plant. In a properly directed foundry, supervisors will aid greatly in reducing the amount of defective castings as well as speeding up the molding, coremaking and other operations. If foremen are not aggressive and are not economical, consistent with the best practice, considerable work can be lost. It also is necessary to maintain a force of workers who are competent and modern in their trade and who can produce quality work. If a number of workers of only ordinary ability are employed, it is all the more necessary to have good supervisors.

One pronounced factor in reducing costs, and increasing profits, is to acquaint foremen with the cost of operating their departments, both with regard to productive and departmental operating costs. The latter comprises many factors such as cost of common labor; cost of supplies used in the foundry to maintain operating equipment; repairs on machinery and equipment; needless running of machinery, waste in use of electric lights, gas, and other power; leaks in compressed air lines; careless piling of castings, miscellaneous equipment, flasks, clamps, sling chains, etc.; and maintenance of proper gangways.

When foremen are furnished with a monthly exhibit of their operating expenses, it awakens a lively appreciation that is reflected in improved conditions. Such improvement means a reduction in expense, that amounts to a sizable sum yearly.

Foundry and pattern shop foremen should co-operate at all time to determine the best method of making patterns to meet foundry needs. Collaboration always is necessary to permit engineering design to be made with due regard to foundry requirements. It also is obligatory on the part of all companies operating an engineering department in connection with their pattern shop, foundry and machine shop, to have their engineers familiar with the best practice in these three divisions.

Cost System Necessary

Another factor that contributes to the prosperity of a foundry is the utilization of a cost system. Modern cost and accounting methods are obligatory if a foundry wishes to produce the best analytical records and equitable costs.

Price cutting is one of the great evils of the foundry industry. It usually is the foundry lacking accurate cost data that is the flagrant offender. Foundries that have equipped their shops with modern equipment and have reduced their costs, deserve no criticism, but other plants, with no cost system, or with an erroneous idea that they can take a lot of work at a low figure and save on overhead cost of operating the shop must be taught better economic practice.

The most successful method of operating a foundry, engaged either in making castings for further conversion into machinery within its own company, or in a jobbing business, is to improve plant facilities. Make castings to specifications and co-operate with competitors in adopting uniform accounting and cost practice. Develop sales policy, giving to customers the benefit of acquired engineering knowledge.

WHAT OTHERS ARE THINKING

Abstracts Selected from the World's Foundry Literature

Studies Cast Iron Structures

Simplified Practice of the Metallography of Cast Iron (*La Pratique Simplifiee de la Metallographie des Fontes*), by F. Girardet. *Bulletin de l'Association Technique de Fonderie*, Paris, July, 1930.

The author, who has had a wide practice of metallography and of the study of cast iron, describes the equipment he uses for the rapid preparation of polished test pieces, his method of obtaining brinell hardness figures on small pieces, and the use of special reagents for the study of micrographs. The test pieces used are of two kinds: the Fremont cylindrical piece of 5.6 millimeters (0.22-inch) diameter, and odd pieces of varied origin.

Special precautions are taken in making the test pieces, which are turned on a lathe. The author emphasizes the necessity of arriving at accurate dimensions for mechanical tests, to obtain comparable results. The pieces are fixed three at a time on a wooden block, and all three are polished together in about 3 minutes.

To obtain a brinell figure on these small test pieces, M. Girardet has built a small machine in which the ball has a diameter of 1.58 millimeters (0.05-inch). The weight suspended at the other end of the lever, and the length of the arm, are such as to give the same brinell figure as would be given by the standard machine. Hardness tests are made preferably on pieces that have been etched to reveal the pearlitic structure, which gives a clearer outline of the ball's indentation.

The pieces are fixed into a block of lead. The author has made as many as 16 hardness tests on a piece of 5.64 millimeters (0.22-inch) in diameter. For micrographic inspection, the test pieces are fixed in a series of 12 in a slab of hard wood, which then is passed under the microscope like a slide.

The article discusses the micrographic investigation of various elements found in cast iron, and the interpretation of results. For graphite, a test piece usually is examined unetched after polishing. However, the author uses a reagent which gives relief to the graphite particles. It is composed of 25 cubic centimeters of pure hydrochloric acid, 100 cubic centimeters of water, 5 grams of anhydrated nickel chloride and 10 grams of chromic acid. After the piece has been attacked, it is washed with diluted ammonia and then with methyl alcohol containing 10 per cent ether. The piece then is dried. It is advisable to repeat the attack rather than to effect one long attack.

For pearlite, a solution of 4 per cent picric acid in denatured alcohol is used. Two reagents are used for steadite and cementite. Reagent *A* is composed of 15 grams of potassium bromide dissolved in 30 grams of water, 15 grams of bromine being added; reagent *B* is composed of 20 grams of caustic soda dissolved in 50 cubic centimeters of water. The test pieces are attacked by a mixture of equal volumes of *A* and *B*, and then washed in dilute ammonia.

Shrinkage Is Determined

The Shrinkage of Copper-Tin Alloys (*Ueber die Schwindung von Kupfer-Zinn-Legierungen*), by F. Boehm and F. Sauerwald, *Die Giesserei*, Dusseldorf, Germany, Aug. 29, 1930.

In a previous article Sauerwald mentioned some of the considerations involved in determining the shrinkage of metals and alloys and described a device for measuring the linear contraction. This article describes investigations carried on employing the device with a number of copper-tin alloys.

Such an alloy composed of 40 per cent tin and 60 per cent copper showed an average shrinkage of 2.38 per cent. The mean shrinkage of the Cu_3Sn alloy (61.64 per cent copper and 38.36 per cent tin) was 2.53 per cent. For Cu_4Sn (68.18 per cent copper and 31.82 per cent tin) the shrinkage determined by extrapolation was 2.02 per cent. Other alloys investigated were the 90 per cent copper-10 per cent tin; 95 per cent copper-5 per cent tin; 96 per cent copper-4 per cent tin, and the 97.5 per cent copper-2.5 per cent tin.

Phosphorus Affects Gun-Metal

The Effect of Phosphorus on the Strength of Admiralty Gun-metal, by H. C. Dews, *Foundry Trade Journal*, London, Sept. 11, 1930.

The effect of several impurities such as lead, arsenic and antimony on admiralty gun-metal have been studied but the way in which phosphorus affects that metal has not received much attention. Since castings made from that metal are accepted or rejected on results of tensile tests giving maximum stress and elongation figures, that test on sand cast bars was chosen by the author to show the effect of that element.

All experiments were carried out under actual working conditions with commercial materials. The alloys were made from ingot copper, Straits tin, spelter, soft lead and commercial 10 per cent phosphor-copper. The melting practice and the method of determining the casting temperature is explained. Heats melted corresponded as closely to the specifications for admiralty gun-metal as the tests permitted. The standard composition was used containing 10 per cent tin, 2 per cent zinc, and 0.5 per cent lead. Zinc and phosphorus losses in melting were allowed in adding those metals to the melt.

Various sized test bars were cast varying the casting temperatures and the melts were analyzed. The author explains the various methods used to conduct the tests and gives data on casting temperature, maximum stress, elongation, brinell hardness and density of the various melts with varying casting temperatures and additions of phosphorus. It was found that there was little change in strength values up to 0.04 per cent phosphorus and that there was a sharp reduction in that value between 0.04 and 0.07 per cent phosphorus. Little further change was noted from 0.07 to 0.13 per cent of that element. Brinell hardness increased with phosphorus additions up to 0.04 per cent and a reduction in hardness resulted with continued additions up to 0.13 per cent. Density did not change with up to 0.06 per cent phosphorus but decreased slightly when that element was increased gradually up to 0.13 per cent.

Microtests of specimens showed that there was no appearance of the insoluble copper phosphide in sand cast gun-metal of the type used until 0.05 per cent phosphorus had been added to the melt.

Describes Core Oven Practice

The Drying of Cores in the Foundry (*Le Sechage des Noyaux de Fonderie*), by Jean Duchaullut. *La Revue de Fonderie Moderne*, Paris, June 25, 1930.

In drying cores the operation must take place from the center of the core outward. If the skin dries first, it hardens and the water inside the core steams out, causing internal stresses and cracking. Oven temperature must be as uniform as possible. Air in the oven must be well agitated, but renewed at intervals as long as possible to avoid frequent introduction of cold air.

The best condition of air circulation in a continuous oven is that in which the current of air circulates in a direction opposite to that of the core conveyor. Frequent opening of core-drying oven doors should be avoided. It is recommended that separate blowers be employed for the introduction and agitation of air in the oven. The air that has been used for drying should be used again by mixing it with the products of combustion, and with a certain proportion of fresh air. That may result in an appreciable economy in fuel consumption. It also is recommended that a cooling zone of approximately one-third the oven length, be provided for the cores. New air should pass through that zone before being mixed with old air. That recuperates the heat from the cores which otherwise would be lost.

The length of time for drying depends upon the size of the cores, the size of the grains of sand, the nature of the core oil and the proportion of water in the cores. By carefully studying various conditions, it has been found possible to reduce the time of drying certain cores materially.

The FOUNDRY Family Photograph Album

Upper Left

W. A. HERSEY

Hersey Mfg. Co., South Boston, Mass.

Upper Right

W. C. SIBLEY

South Bend Foundry Co., South Bend, Ind.

Lower Left

R. MacDONALD

Bethlehem Steel Co., Bethlehem, Pa.

Lower Right

D. P. LANSDOWNE

West Steel Casting Co., Cleveland

TENTATIVE SPECIFICATIONS FOR

Copper-base Alloys in Ingot Form for Sand Castings

1. These specifications cover brass ingot metal for sand castings in fifteen different compositions, regularly sold by the trade and abitrarily herein given numbers one to fifteen inclusive to differentiate them from one another. These numbers have no other significance.

Manufacture

2. The manufacturer shall use care to have each lot of ingot metal as uniform in quality as possible. This metal may be manufactured by any refining process which will yield a satisfactory quality of product.

Table I.—Chemical Compositions of Copper Base Alloys.

Alloy	Copper, per cent	Lead, per cent	Tin, per cent	Zinc, per cent	Impurities, maximum, per cent							Total Constituents, per cent	
					Antimony	Iron	Nickel	Phosphorus	Sulfur	Aluminum	Silicon	Other than Copper, Lead, Tin, Zinc and Nickel	Other than Copper, Lead, Tin, Zinc, Nickel and Antimony
No. 1	Remainder	1.50 to 2.50	9 to 11	1.50 to 2.50	0.25	0.25	0.50	0.03	0.08	0.005	0.05	0.50	....
No. 2	Remainder	1.50 to 2.50	7.25 to 8.75	3.50 to 4.50	0.25	0.25	0.50	0.03	0.08	0.005	0.05	0.50	....
No. 3	Remainder	4.25 to 5.75	5.25 to 6.75	2.50 to 3.50	0.25	0.25	0.50	0.03	0.08	0.005	0.05	0.50	....
No. 4	Remainder	4.25 to 5.75	4.25 to 5.75	4.25 to 5.75	0.25	0.25	0.50	0.03	0.08	0.005	0.05	0.50	....
No. 5	Remainder	4.25 to 5.75	3.25 to 4.75	9 to 11	0.25	0.35	0.50	0.03	0.08	0.005	0.05	0.50	....
No. 6	Remainder	7 to 9	2.50 to 3.50	8.50 to 11.50	0.25	0.35	0.50	0.03	0.08	0.005	0.03	0.50	....
No. 7	Remainder	9 to 11	9 to 11	1.00[a]	1.00	0.25	0.50	0.05	0.08	0.005	0.03	....	0.50
No. 8	Remainder	9 to 11	9 to 11	2.00[a]	1.00	0.25	0.50	0.05	0.08	0.005	0.03	....	0.50
No. 9	Remainder	13.50 to 16.50	7 to 9	2.00[a]	1.00	0.25	0.50	0.05	0.08	0.005	0.03	....	0.50
No. 10	Remainder	18 to 22	5.25 to 6.75	1.50[a]	1.00	0.25	0.50	0.05	0.08	0.005	0.03	....	0.50
No. 11	Remainder	14 to 20	3.50 to 5.50	4 to 6	1.00	0.25	0.50	0.05	0.08	0.005	0.03	....	0.50
No. 12	70 to 75	1 to 4	2.00[a]	Remainder	0.10	0.25	0.50	0.01	0.05	0.005	0.10	0.50	....
No. 13	67 to 70	1 to 4	1.50[a]	Remainder	0.10	0.30	0.50	0.01	0.05	0.005	0.10	0.55	....
No. 14	64 to 67	1 to 3	1.00[a]	Remainder	0.10	0.35	0.50	0.01	0.05	0.005	0.10	0.60	....
No. 15	60[b]	3.00[a]	1.00[a]	Remainder	0.10	0.35	0.50	0.01	0.05	0.50	0.10	1.00	....

[a] Maximum
[b] Minimum

Chemical Properties and Tests

3. The alloys shall conform to the requirements as to chemical composition

Criticisms of these tentative specifications which are abstracted from those accepted by the American Society for Testing Materials are solicited and should be directed to D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Chase Metal Works, Waterbury, Conn. These tentative specifications are, in effect, a revision of the former Standard Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (A.S.T.M. Designation: B 20—22), which specifications were discontinued in 1928.

(*Continued on Data Sheet No.* 834)

TENTATIVE SPECIFICATIONS FOR

Copper-base Alloys in Ingot Form for Sand Castings

(*Continued from Data Sheet No.* 833)

given in Table I, within the limits specified therein.

Note.—The limits specified in Table I indicate the maximum and minimum percentages within which variations of different elements shall be permitted, with the understanding that every precaution shall be taken both in the selection of raw materials as well as methods of manufacture to insure that the resulting ingot metal will come within these specified limits.

Table II—Physical Properties of Copper Base Alloys

Alloy	Tensile Strength, lb per sq. in.[a]	Elongation in 2 in., per cent	Reduction of Area, per cent	Compression Deformation Limit, lb. per sq. in.[b]	Brinell Hardness Number, (500 kg. for 30 sec.)	Shrinkage, in. per ft.	Weight, lb. per cu. ft.
No. 1	32 000 – 38 000	15 – 20	15 – 20	.....	55 – 65	0.125	535
No. 2	30 000 – 36 000	25 – 30	25 – 30	.....	55 – 65	0.125	535
No. 3	25 000 – 33 000	15 – 20	15 – 20	.....	45 – 60	0.140	535
No. 4	27 000 – 33 000	15 – 20	15 – 20	.....	50 – 60	0.140	535
No. 5	29 000 – 35 000	25 – 35	20 – 30	.....	40 – 50	0.140	535
No. 6	22 000 – 28 000	10 – 15	10 – 15	.....	50 – 55	0.125	540
No. 7	27 000 – 33 000	7 – 12	8 – 13	12 500	47 – 52	0.25	553
No. 8	27 000 – 33 000	7 – 10	7 – 12	12 500	47 – 52	0.25	553
No. 9	25 000 – 30 000	11 – 17	10 – 16	12 000	45 – 50	0.25	570
No. 10	22 000 – 27 000	9 – 16	7 – 13	11 000	42 – 47	0.25	570
No. 11	25 000 – 30 000	10 – 15	7 – 13	12 000	47 – 52	0.25	570
No. 12	30 000 – 35 000	35 – 45	25 – 35	.....	40 – 50	0.125	535
No. 13	30 000 – 35 000	25 – 35	20 – 30	.....	40 – 50	0.125	534
No. 14	30 000 – 35 000	25 – 35	20 – 30	.....	40 – 50	0.125	533
No. 15	30 000 – 45 000	15 – 25	20 – 30	.....	40 – 50	0.20	500

[a] The tension tests were made on test specimens taken from ingots. Sand-cast test specimens would show somewhat lower values.

[b] The compression tests were made on machined test specimens (sand castings) of 1 sq. in. in sectional area and 1 in. in height. The compression deformation limit is taken as the load producing a compression in the specimen of 0.001 in. At the request of Committee B-2 on Non-Ferrous Metals and Alloys, Committee E-1 on Methods of Testing is giving consideration to revising the dimensions of compression test specimens and the method of determining the so-called "compression deformation limit." The revision of the values in this column, on the basis of cylindrical specimens 1 sq. in. in sectional area and 3 in. in height is contemplated. A revision of the methods of determining compression information limit is also under consideration.

4. (*a*) Ten ingots shall be selected by the inspector to represent each 40,000 pounds and five ingots shall be selected for less than carload lots.

(*b*) The samples for chemical analysis may be taken either by sawing, drilling or milling the ingots and shall represent the average cross-section of all of the ingots selected for sampling.

(*c*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

(*Continued on Data Sheet No.* 835)

THE FOUNDRY DATA SHEET, OCT. 15, 1930
Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Bill Prescribes for a Cracked Bolster

By Pat Dwyer

THE other day while talking over the phone to Bill, he asked me if I had seen a recent issue of the *Ladies Household Pet*, a national magazine with a wide circulation among women readers.

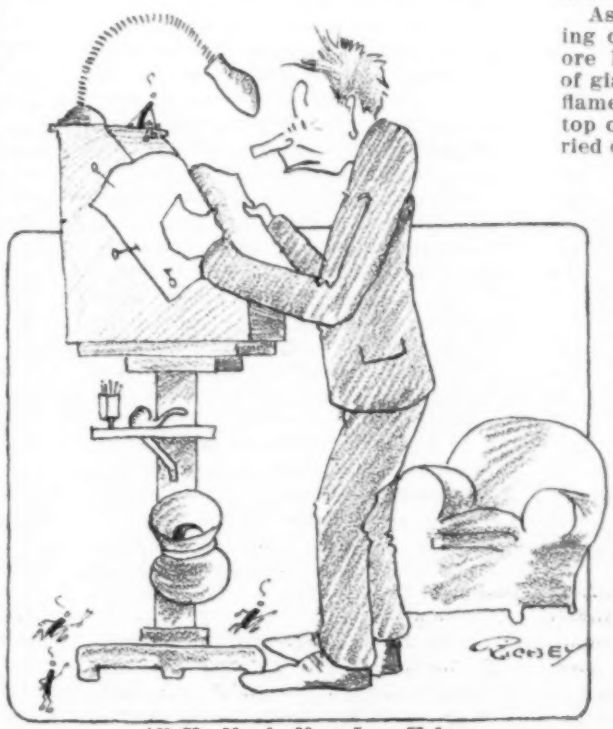
Wondering what he was driving at, I admitted that the magazine had been coming to the house for several years, but I was not sufficiently curious to even flutter the pages and look at the pictures. I had looked through a few of the early issues and had waded through a few of the saccharine and at times neurotic stories, but long ago had decided that life was too short to waste time over stories in which the heroine invariably was the personification of wit, beauty and intelligence and endowed besides with the keenest financial and business instinct, while the hero merely was a poor dumb brute—well dressed of course and a good dancer—with the mentality and accomplishments of a 10-year old child. "Take a look at this one," Bill advised me. "There is an article in it by a woman writer, on the making of steel, that will make you open your eyes." I wasted an hour that night prowling through the current issue, also through half a dozen preceding issues, but failed to find even the remotest reference to steel. I called Bill up and told him the result of my investigation. Furthermore, I told him he was talking through his hat. If it was not too much trouble, would he kindly indicate the page and the issue of the paper in which he had seen this marvelous story. "I'll do better than that, my boy," Bill responded heartily. "I'll bring the thing over tonight and show it to you." He came over to the house last night with the paper in his pocket. "Just a slight technical error," he remarked genially. "Sorry to have put you to all that trouble. This here gem I was telling you about was not in the *Household Pet*. It was in another mess of baloney, *Penelope's Sketches*. They all look pretty much alike on the outside. I am not sufficiently familiar with the insides to venture a comparison.

"In this particular instance my attention was directed to the article to which in turn I directed your attention—"

"You are a grand director—"

"Sez you! Ain't I trying to tell you how it happened? I never read 'em. Do you know why I never read 'em? To save you the brain fatigue of trying to think up a snappy—but totally irrelevant—answer, I'll tell you. All these magazines measure 11 x 14 inches and you might as well try to hold a snake as to hold one of these papers in a comfortable position for reading.

"Probably it could be done by spreading the magazine open on a reading stand and then standing in front of it with your paws spread on opposite pages of the jolly old book to keep them flat—"



All He Needs Now Is a Helper

"Keep what flat? The paws?"

"Certainly not—I'd like to flatten you once — the pages, kid, the p-a-g-e-s, pages. Now, who the—I ask you—who wants to read in that position?"

"Perhaps," I suggested hopefully "perhaps the publishers deliberately selected that size for their magazines. It may be just one of the 57 varieties of the old reliable banana oil. The impression subtly is conveyed that the readers are persons of ease and refinement who do their reading while stretched negligently on so many chaise longues."

"There may be something in that," Bill admitted. "The idea never occurred to me. However, I know one thing and that is you cannot sit in an easy chair with your feet cocked up on another chair and hold the paper with any degree of comfort. It wiggles and squirms around more than a girl receiving her first kiss at a game of post office.

"Anyway," he continued, "that's how I mixed the titles of the two papers. That's my story, and I'll stick to it. Also, as that sterling bard, W. Shakespeare said once upon a time, 'All's well that ends well.' Here's the extract dealing with the manufacture of steel:"

As a pyrotechnic display, the making of steel has no rival. After the ore has been crushed in the maws of giant machines, it is thrown to the flames, where the slag mounts to the top of the seething metal and is carried off. It is then that the great gates of the furnace open, and rivers of fire come surging forth, sending showers of green and blue and orange sparks in the air. Sizzling and roaring it flows between brick lined bed and bank into bells wide and deep from which it is poured into molds. As "Pig" or ingot it comes forth, red hot, to be taken up by the rollers and passed back and forth like fiery serpents, hissing and writhing until it is reduced to its proper dimensions. Space does not permit a comprehensive story of the steel industry, but even a short trip through the mills reveals to the inquiring mind the wonder and glory and the unending toil by which man makes all things obedient to his needs.

"As a pyrotechnic display?"

said Bill, "the making of steel has no rival, but then again on the other hand, so far as I know, this description has no rival either. The author with the true inquiring mind saw more in that short trip through the mills, than genuine old mill men have seen in whole course of their lives.

"At one time or another highly accomplished men have spent immense amounts of money in a vain endeavor to make steel direct from iron ore and yet this lady saw it done on the first and only trip she ever made through the mills. I am afraid some big steel interest will grab her one of these days and have her cut out the open hearth even as she banished the blast furnace. By mixing the ore (presumably steel ore) with a little suitable googum, crushing it a little finer and heating it a little hotter, it can be fed directly to the rolls.

"It would be a pity to cut out the open hearth and thus cheat future visitors who wished to see the great gates through which the rivers of fire come surging forth. Second helpers, whose job is to make up the tap hole after each heat will be greatly interested in the proper operation of these gates. The green and blue and orange sparks also are a decided innovation. Steel men think these sparks are white, but then of course they are not gifted with the marvelous eye of the writer. An eye which can break down these dazzling white sparks into the various colors which make up the spectrum.

"What burns me up, is the sublime confidence shown by authors of this kind. They go through a steel mill in 20 minutes and then write—what they think is—a description of the steel making process. They miss the first step, make a mess of the second and foozle the third. The manufacture of steel and—so far as we are concerned—the manufacture of steel castings, is a very good field for the layman or laywoman, to avoid. Even those with a fairly comprehensive knowledge of the subject, sometimes have their fingers burned.

"I had an inquiry the other day from a lad in a foreign country who was having his own share of trouble with steel bolster castings. He sent me a free hand sketch with a few measurements and the location of the defect. Here I'll show it to you and you can see for yourself what caused him to send out the clarion call for enlightenment."

He fished around in his various pockets and finally found the sketch which—I hope—is reproduced somewhere on this page. Nothing is more embarrassing to an author than to refer in his text to Fig. so-and-so and then discover to his horror that the make-up man, or his helper, has omitted to include the Fig. on the page.

It is just as easy for a makeup man to slip in this respect as it is for a molder to lose one of the loose pieces on a pattern, or to forget to cut a gate. Also the average makeup man usually grades higher than the average molder in general intelligence and for that reason he is more skillful in presenting an alibi at the post mortem. You have just as much chance of catching a weasel asleep—yes, 40 adult weasels—as you have in trying to pin anything on one of these suave, sophisticated birds who juggle type.

His first alibi is that the thing was not on the dummy. At the expense of a great deal of time and earnest exploration through a bushel of loose sheets you discover the particular dummy sheet and show it to him triumphantly. Is he convinced? He looks you coldly in the eye and inquires pointedly why the proof reader did not discover the error.

She Saw It Done with Her Own Little Eyes

Always optimistic — one eye out for the silver lining and all that kind of thing—you reflect that if the error passed the eagle eye of the printer and the proof reader, the chances are in your favor that the ultimate reader also will miss it.

The days pass as days have a habit of passing and then the blow falls. You open a letter in which a peevish gent wants to know whadda ya mean by talkin' about Fig. so-an'-so when there ain't no Fig. so-and-so in the whole mess of tripe. Just try to laugh that one off by reaching nonchalantly for one of your favorite smellirinos.

"There it is," Bill continued. "The upper view, just as I received it. In the lower view the four triangular black areas were added before I made a copy to send the inquirer. These four black areas constitute the remedy I prescribed. I'll come back to them again.

"He did not forward the analysis of the metal, the style of gate and risers, whether the mold was made in green or dry sand, the method of molding, or several other factors which possibly might have a bearing on the problem. The letter head stated that his company made electric steel and I had to assume that the metal is melted in an electric furnace, a distinctly different practice from that pursued in this country where practically all the metal for railroad castings is melted in the open hearth.

"In fact the letter was so brief I had scarcely anything on which to base a diagnosis. Of course I appreciated the compliment to my omniscience, but, dash it all, a fellow has to have a few facts before he ventures an opinion. Even a doctor has to prod and poke, look at your tongue, smell your breath and ask you a string of intimate and sometimes embarrassing questions before deciding whether the shooting pains in your legs are due to fallen arches, infected teeth or a dog bite.

"To arrive at a perfectly satisfactory opinion and prescribe a remedy I should like to stick around the foundry for a day and check up on the many variables that enter into the production of the castings. Sometimes an apparently unimportant factor is responsible for all the trouble. When that is remedied, the castings come out as smooth and slick as an onion and every one from the G. M. to the apprentice boy says: 'You know, I thought that was the trouble all the while, but no one would listen to me!' I'll read you the letter. Here, listen:

Our foundry is making bolsters for the state railways and we have lots of trouble with this material, principally from small cracks which appear on the surface as per sketch. I should be very pleased to know if there are any means to avoid this trouble and if in the United States the railroad inspectors permit welding in such cases. Most of the cracks have an extension of about 4 inches.

"There you are, my lad, the whole story. The castings crack and how are you going to stop 'em?"

"Well," I admitted cautiously. "That's a rather tough assignment. What did you tell him?"

"Why," said Bill. "I kind of figured under the circumstances the best reply to the inquiry would be a brief outline of American practice on these castings.

"The general practice in practically all shops engaged in the production of bolsters in green sand molds is to keep the side walls a full 1/32-inch under the dimension shown on the drawing. If necessary the additional thickness is placed on the top or bottom if a definite weight for the casting is specified. In any event the side wall thickness as shown on the pattern and corebox is reduced. The pressure of the metal in the

mold will bring the sides back to the specified thickness.

"Hard cores will cause the castings to crack. They should be checked for hardness and should be well vented. Wherever practical, green sand cores are employed in preference to dry sand cores. If an entire green sand core cannot be employed, it often is possible to employ a combination dry and green sand core. A dry sand bottom half can be topped with green sand or several dry sand sections can be incorporated at strategic points in the green sand core.

"The side wall thickness in the assembled mold should be checked with suitable gages to see that no uneven condition exists due to a faulty setting, or a tilt in the core.

"Sand should be sufficiently refractory to strip clean from the casting. Any sand that burns to the face, the kind that sticketh closer than a brother, is not suitable for these molds. It will retard normal contraction and cause the casting to crack. The swell in the center of the casting and the vertical strips near the ends set up a certain amount of resistance to the natural pull of the metal and facilities should be provided to reduce that resistance to a minimum. The furnace practice and the analysis of the metal should be checked to determine if the trouble originates in that department. The sulphur should be held to 0.03 per cent and certainly should not run over a maximum of 0.036 per cent.

"If the sand, metal and molding practice measure up to requirements and the cracks still appear, it may be necessary to ram shrinkage blocks in the drag, introduce cracking strips at the defective areas, or incorporate short lengths of wire in the casting at the points where the cracks appear.

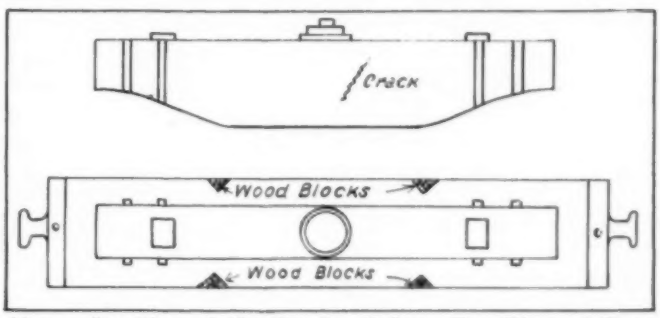
"Four tapered, triangular wood blocks, 4 inches on each side and a little longer than the depth of the casting, are placed in the drag in the position shown in the lower part of the sketch. After the bolster pattern is withdrawn, these blocks also are pulled out and the cavities filled with soft sand. These weakened areas allow the sand to *creep* a little while the casting is contracting.

"The term *cracking strip* really is a misnomer, since its object is to prevent the casting from cracking at the point where the strip is applied. Like many other foundry terms, right and wrong, this term has become established firmly through universal usage over a period of many years and every steel foundryman knows exactly what it means.

"A cracking strip is a thin web or fin, cut in the face of the mold at a point where a crack is anticipated in the casting. It is cut at right angles to the anticipated crack. This thin web sets almost immediately and acts as a tie or reinforcement to prevent the metal in the immediate vicinity from cracking.

"In the bolster casting the cracking strips are formed in the core. They may be cut with a tool while the core is green or formed by placing suitable wood strips in the corebox. In a complete dry sand core they may be cut with a file after the core is dried. The advantage of placing the cracking strips in the core is that they do not have to be removed from the casting, as would be necessary if they were cut in the face of the mold.

"Short lengths of soft steel wire 3/16-inch diameter sometimes are employed instead of the cracking strips. The wire is bent to form a toe at each end and these toes are pushed into the sand so that the wire occupies a space in the mold cavity and straddles the anticipated crack in the casting and thus prevents it.



Above—Location of the Crack. Below—Top View of Drag with Preventive Wood Blocks in Place

"Castings cracked in the manner shown in the upper sketch would not be passed by inspectors in the United States. Instructions laid down by the Master Car Builder's association are very rigid. Diagrams are furnished showing the restricted welding areas and no crack over 2 inches in length may be welded. Also the crack must be shown to the inspector before any attempt is made to weld it.

"Half the weight of the railroad car rests on the center of the bolster. This weight is distributed at the two ends on the side frames and the side frames in turn rest on the journal boxes in which the ends of the axles revolve. Thus in addition to bearing one half the weight of the car, the bolster is subjected to the constant vibration from the four wheels of the truck and the shock that results from each one passing over a rail joint.

"Manifestly nothing but a sound, homogeneous and exceedingly strong casting is capable of withstanding such severe service. Considering the rigid specifications to be met and the exceedingly narrow margin that lies between success and failure, the fact that thousands of these castings are turned out satisfactorily every day on a mass production basis, constitutes a distinct and notable tribute to the technical and practical knowledge and skill of the foundryman."

Readers Comment

Note—Material appearing under this head does not necessarily reflect the opinion of THE FOUNDRY or its editors.

TO THE EDITORS:

A number of electric furnace duplexing installations are in regular operation aside from that of the Ford Motor Co. At least one of these installations seems to fit exactly the conditions which the inquirer had in mind in the question, "Uses Electric Furnace," which appeared in the July 15 issue. Namely a small unit which will give about 200 pounds of metal per tap at regular intervals throughout the day.

One large manufacturer in the Pittsburgh district is using two rocking electric arc furnaces exclusively for duplexing molten cupola iron. One of these rocking furnaces handles from 200 to 300 pounds of molten metal per heat, mixing and superheating the cupola iron in the manufacture of piston rings exclusively. This furnace has been in production for more than three years and during this period has been producing results regularly and consistently. The other rocking furnace in the same plant is duplexing cupola iron with suitable cold scrap additions in the production of high-strength iron of 50,000 to 60,000 pounds per square inch tensile strength for the manufacture of special castings.

Recently an additional gray iron duplexing installation has been put into service in the Detroit district. This furnace is of 5000 pounds holding capacity and gives a production of 2000 pounds every 20 minutes elapsed time. The molten cupola metal is superheated approximately 350 degrees Fahr. while suitable cold additions are made in the electric furnace to adjust the composition in accordance with established requirements.

ALBERT E. RHOADE
Detroit Electric Furnace Co.
Detroit

Moves Offices

Philadelphia Hardware & Malleable Iron Works, Philadelphia, has moved its offices from Ninth and Jefferson streets, to State road and Shelmire, Tacony, Philadelphia.

Corundite Refractories, Inc., has arranged for installation of a tunnel kiln at its Massillon, O., plant.

The Shakeout

DAN M. AVEY, *Editor*
FRANK G. STEINEBACH, *Managing Editor*
PAT DWYER, *Engineering Editor*
EDWIN BREMER, *Metallurgical Editor*
CHARLES VICKERS, *Nonferrous Editor*
NORMAN F. HINDLE, *Assistant Editor*

¶ Safety Enforcement Pays

ACCIDENT prevention in the foundry means the continued application of safety principles every hour of the working day, and not a strenuous campaign of just a week or a month after which the ideas lie dormant until the next drive. Safety should begin with the man highest up and not the reverse. Leadership is a valuable quality, and it hardly can be expected that the rank and file will exert the necessary caution if they observe the president, manager, superintendent and foreman carelessly breaking the safety rules.

ACCIDENTS not only deprive the individuals from earning their livelihoods for a short or protracted period, but cause considerable inconvenience in the usual shop routine through the necessity of filling the injured person's place until he is fit for work again. Also, there is the matter of compensation. While that item usually is cared for by some form of insurance, it may be pointed out that the premiums paid are based on the accident rate. Consequently, the less accidents, the lower the rate. As an illustration of the benefits derived from strict enforcement of safety principles, one Ohio foundry had its rate reduced from $1.80 per $100 of payroll to $1.03. To paraphrase a well known advertisement—The Saving Will Pay for New Equipment.

¶ Making Things Lighter

PRELIMINARY reports of the department of commerce, bureau of census, indicate the continued gain in popularity of aluminum products. From 1927, when the last previous census was made, until 1929, the value of material shipped or delivered by establishments engaged primarily in the manufacture of aluminum products increased 19.2 per cent, the value in 1929 being $147,307,270. A study of the various classes of production shows that aluminum castings were an important factor.

THE total value of aluminum ware, including cast, stamped and spun products, was $35,784,130. This output is made up of both electrical kitchen and household appliances as well as other such appliances. Motor vehicle accessories and parts, which were made of aluminum, were valued at $11,719,444. Rolled forms, bars, rods, plates, sheets, wire and ingots totaled 71,370,236 in value. Castings, not included in the other classifications, were valued at $21,164,807. While castings have not been completely segregated as a class of manufacture, the preliminary reports indicate that casting probably has made as great a gain as any other process for fabricating aluminum.

¶ Once Every Seven Years

ONCE every seven years, styles are said to repeat themselves, or to approach a similarity which sustains this theory. This is only another statement of the principle that there is nothing new under the sun. The recent revival of interest in cast iron dogs is a case in point though the cycle of change is longer. Ornamental castings, of iron, malleable, steel, copper or bronze always are in good taste and much originality has been shown in keeping abreast of taste in home building decoration in recent years. The first horn-type loudspeaker for radios were castings. Newer types of small sets are featuring decorative screens in which castings carry out the designs. Similar changes in taste in more utilitarian commodities will occur to mind. The lesson to be gleaned—and of course there must be a lesson—is to study old uses as a basis for the development of new casting requirements.

¶ Buildings Are Cheap

INDUSTRIAL building costs are the lowest in eight years, according to a survey recently conducted by a large engineering and construction company. Except for a period in 1922, costs have not been as low as at present since 1916. According to the report, the decline is due to falling prices of materials and the greater efficiency of labor and construction equipment. A modern factory building, 200 x 100 feet, constructed of steel and concrete can be erected in the average midwestern city for $1.40 per square foot against $1.87 in 1923, $2.65 in 1920 and $1.00 in 1913.

POOR lighting facilities, crowded floors and obsolete equipment cut efficiency and increase costs. Foundries operating under those conditions and competing with up-to-date and efficient plants soon find that they are not getting their share of the foundry business. Such shops should avail themselves of the low cost of building and erect modern plants with new equipment. Operators will find that a modern shop will pay dividends in personal pride, contented workmen, reduced costs and increased business.

Comings and Goings of Foundrymen

Men of the Industry, Whose Activities Are Making Foundry History

J. RALPH PATTERSON, formerly manager of alloy sales for Mackintosh-Hemphill Co., Pittsburgh, was elected manager of roll and alloy sales, following the resignation of Fred Griffiths, formerly manager of roll sales. Mr. Patterson was born in Beaver, Pa., Feb. 12, 1895, and attended the Beaver schools, graduating from high school in 1913. His first connection was with Pittsburgh Crucible Steel Co., Midland, Pa., in the civil engineering and construction department, for two years. He then became connected with the construction department of the Aliquippa works, Jones & Laughlin Steel Corp., Pittsburgh, for one year, during the building of the pipe and tube mills. In 1916 he became affiliated with the Pittsburgh Iron & Steel Foundries Co. in charge of the engineering and estimating departments, which position he held until 1922, when the company was absorbed by Mackintosh-Hemphill Co. In 1922 he was appointed assistant manager of alloy sales; in 1926, manager of alloy sales; and on Sept. 8, 1930, manager of the roll and alloy sales department.

S. A. Welvang has been appointed purchasing agent for the Rich Mfg. Co., 3855 Santa Fe avenue, Los Angeles, to succeed C. A. MacMillan, resigned.

F. J. Britts, formerly representative for the Mechanical Pattern & Foundry Co. Inc., Los Angeles, has accepted a position as foundry instructor in the Manual Arts High school, Los Angeles.

R. C. Force, president of the Caterpillar Tractor Co., Peoria, Ill., since the present company was formed has been elected chairman of the board. B. C. Heacock, vice president, succeeds Mr. Force.

D. W. Ardiana, formerly connected with the Kay-Brunner Steel Products Co., Los Angeles, has been appointed representative for the Mechanical Pattern & Foundry Co. Inc., Los Angeles, to succeed F. J. Britts.

Frederick M. Kreiner was elected a vice president of Manning, Maxwell & Moore Inc., New York, machine dealers and builders, at a meeting of the executive committee Sept. 23. Mr. Kreiner will continue his duties as treasurer, a position he has held since 1920. He has been connected with the Manning, Maxwell & Moore organization since 1903.

Warren Maxwell, formerly assistant superintendent, Dodge works, Link-Belt Co., Indianapolis, has been appointed superintendent to succeed the late F. J. Oakes. Mr. Maxwell was born in Rockville, Ind., in 1889 and attended Marion Military academy, Wabash college, and the U. S. Naval academy, Annapolis, Md. He joined the sales department of the Link-Belt company in 1922 and was appointed assistant superintendent in 1929.

Charles A. Gutenkunst, formerly vice president and secretary, Milwaukee Malleable & Grey Iron Works, Milwaukee, has been elected president and treasurer to succeed the late William Gutenkunst, whose death was noted in the Oct. 1 issue of THE FOUNDRY. E. W. Gutenkunst has been elected vice president, and C. A. Gutenkunst Jr. secretary. Frank W. Fellenz, president, Fellenz Coal & Dock Co., Milwaukee, has been added to the board of directors. These officers and directors also have been elected officers and directors of Milwaukee Hay Tool Co., Milwaukee, an affiliate of Milwaukee Malleable & Grey Iron Works.

Book Review

Gmelins Handbuch der Anorganischen Chemie, Eisen, Teil A, Lieferung 2, paper, 88 pages, 6¾ x 10 inches, published by Verlag Chemie, Berlin, Germany, and supplied by THE FOUNDRY, Cleveland, for $4.25 plus 15 cents postage.

This volume is a continuation of section 1 of part A of Gmelin's handbook of inorganic chemistry dealing with iron. It deals with the physical properties of pure iron with data on its atomic structure, allotropic modifications, crystallographic properties, mechanical and thermal properties, optical properties, and magnetic and electrical properties. A section of the book is devoted to the electrochemical behavior of pure iron, and another section to its chemical behavior.

Steel Founders To Meet

Steel Founders Society of America will hold its October meeting at the Hotel Roosevelt, New York, on Oct. 22 and 23. W. H. Worrilow, Lebanon Steel Foundry, Lebanon, Pa., vice president and chairman of the Eastern division of the society, will preside. Speakers at the general session include Arthur Marks, Boston; Clark McKercher, New York; Harold S. Falk, Falk Corp., Milwaukee; and Frank D. Glosser, Commercial Steel Casting Co., Marion, O. Meetings of the merchandising and technical research committees, board of directors, and producers of large and small castings will be held.

The newly organized heat and corrosion resistant alloy founders' division of the society will hold a meeting in the general offices of the society on Oct. 24. H. S. Bartholomew, cost consultant for the society, will discuss uniform cost accounting for alloy steel foundries. Thomas R. Hayward, Foundry Co., Pittsburgh, is chairman of the alloy division.

Ferrous Flanged Valves To Be Standardized

The American Standards association, 29 West Thirty-ninth street, New York, has appointed the sectional committee on pipe flanges and fittings to take over the standardization of the face to face dimensions of flanged valves. Among the types that will be included in the investigation are ferrous gate, globe, angle and check valves having flange connecting ends and with ratings of 125 and 250 pounds per square inch. The subcommittee of the sectional committee has considered the question of center to face dimensions of iron and steel check valves for steam pressures less than 400 pounds per square inch and center to face dimensions of 150 pound steel flanged globe and angle valves. The Manufacturers Standardization Society of the Valve and Fittings Industry, one of the sponsors of the work, does not favor the work of the subcommittee on either subject.

Foundry Completes 100 Years of Business

Ulster County Foundry Corp., 20-40 St. James street, Kingston, N. Y., this year completes its first hundred years in the foundry business and will begin the second with a reconstructed plant, doubling its capacity. The building will be strengthened to permit the installation of a 5-ton crane and modern machinery. According to E. M. Hicks, vice president and general manager, the production of a new line of equipment, complete from casting to machining, will be undertaken. E. H. Mayes, 50 Church street, New York, is president.

OBITUARY

Herbert U. Durant, for the past 15 years superintendent of the Baker Iron Works, Los Angeles, died Aug. 8. He was 58 years old.

James E. Evans, S. Obermeyer Co., Chicago, died Sept. 17 after a brief illness. Mr. Evans was connected with the Obermayer company for almost 40 years and was especially well known in the Chicago territory where he had represented the company.

Charles Curtis Coventry, president and treasurer, the Cleveland Tool & Supply Co., Cleveland, died Sept. 18, after a brief illness. He was one of the organizers of the Cleveland company and had been treasurer since its inception and president since 1901. He was born in New Philadelphia, O., and went to Cleveland when the Cleveland Tool & Supply Co. was organized.

Nonferrous Mixtures Are Important

By Gus Burns

Phosphor bronze is a prolific trouble maker where proper precautions in melting and pouring are not observed. Most of the trouble is caused by pouring the metal too hot. The practical man does not need a pyrometer on any of the red or yellow metals. The trained eye is sufficient. Bronze should not be poured while it is smoking. The crucible should be allowed to stand until the smoking stops and the metal becomes a dull red on top. If this metal is allowed to get so hot in the furnace that it smokes, the chances are that it is spoiled and if poured, will produce spongy castings. In charging a pot with phosphor bronze, a quantity of fine charcoal should be placed in the bottom of the pot. This insures a cover for the metal from the time it starts to melt. The cover should be maintained until the pot is removed from the furnace. Contrary to popular belief, straight brass presents difficulties if it is not melted and poured properly. Molds must not be rammed hard. This metal, particularly in thin sections, will not run in a hard mold. Light ramming is essential in the vicinity of the sprue. Hard sand at this point will cause the metal to jump and result in missruns. Many lost castings are blamed on dull metal, when in reality the metal may have been at or even above the required temperature, but the mold has been too hard. No pyrometer is needed to check the proper pouring temperature of this metal. Many foundrymen think that yellow brass cannot be poured too hot, but that idea is mistaken. This metal develops quite a lot of smoke. If the smoke is so dense that the metal cannot be seen, then the metal is too hot to pour. A sight of the metal through the smoke is the signal to commence pouring.

On small and thin castings the stream should be started gently. Then the sprue should be filled and kept full. This method produces a little scrap on top of the mold or on the floor, but it is better to have it there than inside the mold. The following mixtures have proved eminently satisfactory when handled according to the foregoing: Bearing bronze, copper 90 pounds, tin 10 pounds, phosphor copper ¼ pound. Straight brass mixtures: (1)—Copper 70 pounds, zinc 30 pounds; (2)—copper 66 pounds, zinc 33 pounds, lead 1 pound; (3)—copper 50 pounds, zinc 50 pounds; (4)—copper 40 pounds, zinc 60 pounds. No. 3 is known as high brass and No. 4 as white brass.

Mechanical Engineers Elect Officers

The American Society of Mechanical Engineers, 29 West Thirty-ninth street, New York, has elected the following men officers of the society for 1931: Roy V. Wright, managing editor, Railway Age, New York, president; William A. Hanley, chief engineer, Eli Lilly Co., Indianapolis, Thomas R. Weymouth, president, Oklahoma Natural Gas Corp., Tulsa, Okla., and Harvey N. Davis, president, Stevens Institute of Technology, Hoboken, N. J., vice presidents; W. L. Batt, president, S K F Industries, Inc., New York, H. L. Doolittle, chief designing engineer, Southern California Edison Co., Los Angeles, and H. L. Whittmore, chief, engineering mechanics section bureau of standards, Washington, managers; and W. R. Webster, Bridgeport, Conn., R. V. Wright, New York, J. W. Roe, New York, Robert Yarnall, Philadelphia, E. N. Trump, Syracuse, N. Y., B. E. Hull, Houston, Tex., E. O. Eastwood, Seattle, Wash., W. Trinks, Pittsburgh, Warner Seely, Cleveland, and William S. Conant, Washington, as representatives to the American Engineering council.

Makes New Deoxidizer

Electro Metallurgical Sales Corp., 30 East Forty-second street, New York, now is manufacturing silico spiegeleisen on a production basis at its Canadian plant. This ferroalloy contains 7 to 8 per cent silicon and 25 to 30 per cent manganese and is used as a furnace deoxidizer in basic open-hearth steel. That company also has placed in production a new calcium-manganese-silicon ferroalloy containing 19 per cent calcium, 10 per cent manganese and 60 per cent silicon. This is for use as a ladle addition.

Report Credits Goggles for Eyes Saved

The report of a study entitled "Eyes Saver in Industry," published recently by the National Society for the Prevention of Blindness and the National Safety council tells how more than 10,000 eyes and at least $46,000,000 were saved in two recent years among 583 plants employing a total of half a million workmen. In this study it was assumed that an object which hit a goggle lens with such force as to pierce or shatter the lens would most certainly have so damaged the eye, if the goggles had not been worn, as to cause complete or nearly complete loss of vision. It was assumed, further, that every instance of a goggle lens be spattered by molten metal or by corrosive or otherwise injurious chemicals, represented an eye saved. Many plants reported they were using nonshatterable lenses. These and, in fact, the lenses of ordinary goggles and masks may be struck dozens of times by large pieces of metal without being pierced or shattered. Any estimate of the number of eyes saved in industry based on the record of goggle lenses broken, shattered, etc., is conservative.

Faked Foundry Facts

Time Work

Core Oven Heater Has Automatic Control

Willsea Works, Rochester, N. Y., recently developed a new type heater for core and mold ovens. With this type of furnace it is claimed that cores may be loaded in the oven indiscriminately up to 3 x 4 x 4 feet without burning or underbaking. The desired temperature is secured automatically

The Heater Occupies a Small Amount of Floor Space

after setting the control instrument for the temperature required.

Grates and forced draft are designed to prevent the formation of ash particles large enough to extend across the grate openings. The entire grate area is subjected to a uniform, high pressure which is said to assure steady, complete burning for any length of time regardless of the accumulation of ashes on the grate or the amount of fuel in the fire pot. Even though force draft is used, the firing door may be opened with safety during operation, since the construction of the furnace precludes any blast of flames from the door. As the gases leave the fire bed, they are subjected to a second combustion which is claimed to assure generation of the total heat in the coke.

The lever on the side of the unit, shown in the accompanying illustration, is used to agitate the grate mechanism. Ashes are removed through the bottom door. Air, which has given up its heat and taken up moisture, is segregated from incoming air. Waste air is eliminated without disturbing convection of the useful air or carrying that air out of the oven with it. A small sized blower is required to force the heated air into the core oven.

The outlet for waste air during the heating period is constructed so that after moisture has been removed from the cores, natural draft furnishes the small amount of heat required to compensate for the radiation loss. Oxidation of the core oils take place during that period and ample preheated air for second combustion provides a large volume of oxygen.

Introduces a New Sand Mixing Machine

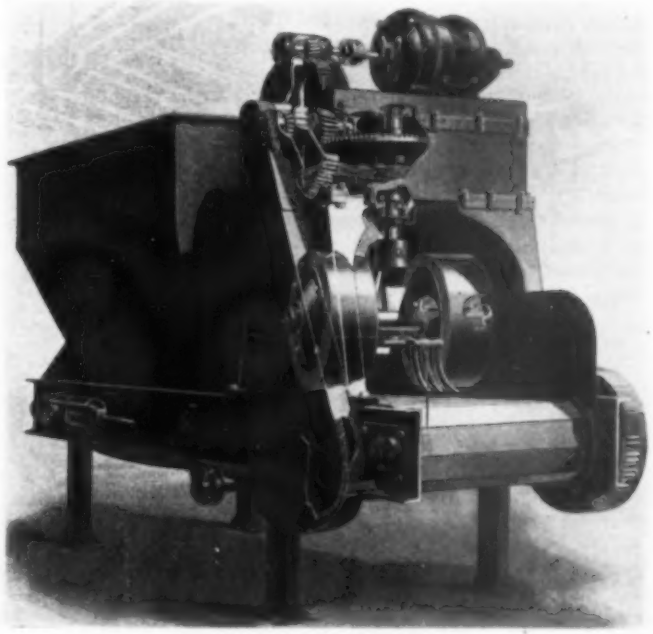
A sand milling machine designed to supply mulled sand continuously has been added to the line of foundry machines made by the Beardsley & Piper Co., Chicago. The equipment has three parts, namely the mullers; and endless apron conveyor mounted underneath the muller; and a sand storage hopper located at the end of the apron. A heavy semisteel casting supports the driving mechanism of the muller unit. It serves as the base of the driving motor and is provided with leg supports that are mounted on the main frame of the apron conveyor. The muller wheels are suspended from the gear housing. They are self-aligning and adjustable for wear. Bearings for the shaft driving the muller shaft are of the roller bearing type and were supplied by the Timken Roller Bearing Co., Canton, O.

Helical-cut gears of heat treated steel serve as motor pinion and gear. The bevel pinion and gear have machine cut teeth. All gears and shafts run in an oil bath which also oils the roller bearings automatically. The bevel pinion shaft is extended through the side of the gear housing and drives the apron conveyor. Muller wheels are provided with heavy rubber tires. Tires are secured in place by four holding lugs identical to standard automobile rim practice. That feature makes the tires easy to remove and renew.

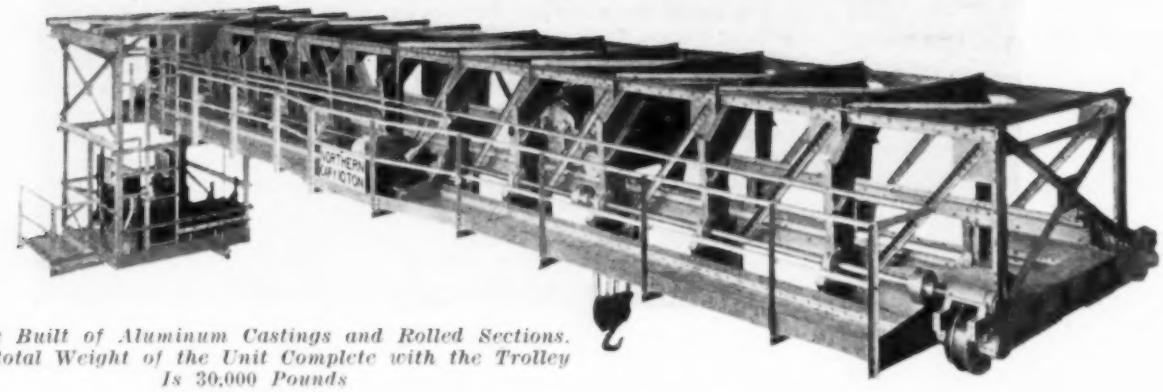
The muller is mounted on the endless apron conveyor which consists of a steel apron carried on three strands of heavy roller chain and is secured to the apron by attachment links. The chain travels on 60-pound, railroad, rails which form a level support for the apron. Tops of the apron are protected from wear by ⅜-inch wearing plates which are renewable easily. That method of construction is claimed to provide a smooth even top for the conveyor and to allow the sand plows to be operated at a position ¼-inch above the conveyor. Drive for the apron conveyor is obtained from the extended muller drive shaft by a roller chain and spur gears. It is claimed that by this method any ratio of mulling can be obtained by changing one sprocket.

The sand hopper, located at one end of the apron conveyor, has a capacity of five tons and is provided with a gate and leveling device on the discharge end which control the distribution of the sand on the conveyor. Any depth bed from 1 to 6 inches may be obtained. It is stated that 4 inches is the correct-depth for proper mulling. The muller, conveyor and hopper are mounted on a heavy rigid, fabricated, steel under-structure designed to withstand heavy loads. Legs are designed so that the machine may be adapted to practically any type sand system.

The entire unit is driven by a 15 horsepower motor travelling at 1200 revolutions per minute. Exposed gears, chains and sprockets are guarded to protect workmen. Space is provided between the storage tank and the muller unit for adoption of mechanisms for adding sea-coal,



The Unit Is Designed for Installation with Any Sand Handling System



Crane Built of Aluminum Castings and Rolled Sections. The total Weight of the Unit Complete with the Trolley Is 30,000 Pounds

bonding material, water, etc. The leveling gate on the hopper is adjusted to allow a uniform flow of about 4 inches of sand to the apron conveyor which travels at a rate of approximately 13½ feet per minute and conveys the sand directly under the rubber tired mullers. The sand is mulled and plowed approximately 20 times before it is discharged from the end of the conveyor.

The muller described has a capacity of from 20 to 40 tons per hour. Where conditions warrant, a twin unit consisting of two sets of mullers, a conveyor speed of 26 feet per minute, and a capacity of 80 tons per hour can be supplied.

Crane Is Constructed of Fabricated Aluminum

Northern Engineering Works, Detroit, recently built six cranes entirely of aluminum for the Aluminum Co. of America, Pittsburgh, for installation in Alcoa, Tenn., plant. A view of one of the cranes is shown in the accompanying illustration.

The crane bridge, which is of latticed type girder construction with overhead bracing, is 76 feet 6 inches between trucks. The bridge is made of rolled, aluminum structural, sections and all electric conduit and fittings are of that metal. Trucks carrying the bridge are aluminum castings. Gear housings, gear covers, bearing housings, transmission cases and covers, and line shaft bearings are made from aluminum alloy. The main drive shaft, which extends the entire length of the bridge and drives both end trucks, also is made of aluminum and is hollow. It is carried in self-aligning, bearing journals spaced at regular intervals along the bridge girder. Bridge and trolley are equipped with roller bearings made by the Hyatt Roller Bearing Co., Newark, N. J. and have forced lubrication.

In the type construction used on the crane illustrated, the crane trolley runs between the girders on beams and rails attached to them. The trolley used on that type crane was made by the Northern Engineering Works and is fully enclosed. The trolley trucks, which include the lower portion of the gear housings, gear housing covers, bearing housings, and connecting girt between the two trolley frames are aluminum castings. The trolley is made with two girts both of which are made of aluminum. One girt is a cast aluminum alloy member that connects the two trolley sides and holds them in alignment. It also carries the hoist motor but does not carry any of the live load. The other girt is made of structural aluminum and carries the live load directly to the trolley sides. That girt is free to adjust itself to varying stresses and is claimed to give permanent alignment for the trolley and its mechanism.

Hoist and traveling mechanisms also are equipped with roller bearings. The hoisting mechanism lifts the hook 25 feet. Three mill type motors for 220-volt direct current drive the hoist, bridge and trolley. They are provided with magnetic control which is located in the operator's cab at one end of the crane bridge.

The hoist operates at a full load speed of 50 feet per minute and is provided with a 19 horsepower motor; the bridge travels at a speed of 400 feet per minute under full load and also is driven by a 19 horsepower motor; the trolley travels at a rate of 150 feet per minute and is driven by a 4¼ horsepower motor.

Book Review

Metallurgy of White Metal Scrap and Residues, by E. R. Thews, cloth, 383 pages, 6 x 9 inches, published by the D. Van Nostrand Co., New York, and supplied by THE FOUNDRY, Cleveland, for $5.65, and in London by the Penton Publishing Co. Ltd., 416-17 Caxton House, Westminster, for 27s 12d, postage extra.

Although scrap and residue treating is becoming an important industry in the metallurgical field, there seems to be little literature available on the subject. This new volume, therefore, will be of considerable value to those engaged in reclaiming metals and alloys from scrap metals and residues. The different types of white metals are treated in separate chapters and the author gives the necessary information for the recovery process without going into too much detail.

Issues Catalog on the Use of Monorails

Louden Machinery Co., Fairfield, Iowa, has issued a 62-page booklet on the uses of its monorail equipment in various industries. The booklet tells why material handling equipment is necessary in modern plants and gives the advantages and adaptability of equipment made by that company. Another portion of the booklet describes the use of monorails in handling raw materials; handling materials through process, assembly, from assembly to packing, and assembly to shipment; use of material handling equipment in plant service and in warehousing. Savings where monorail equipment made by the Louden company has been installed is related in another section of the catalog. The final two chapters of the booklet are devoted to a list of users of equipment made by the Louden company and to the factors underlying the success of monorail installations. The booklet is illustrated profusely with views of typical installations.

Preheat Cupola Blast

The engineering experiment station, Michigan State college, East Lansing, Mich., recently has published a bulletin entitled "Study of Preheating the Blast for Iron Foundry Cupolas," by F. G. Sefing and M. F. Surls. Data were obtained from a cupola lined to 14 inches and showed a fuel saving of 20 per cent due to preheating the blast.

Builds New Offices

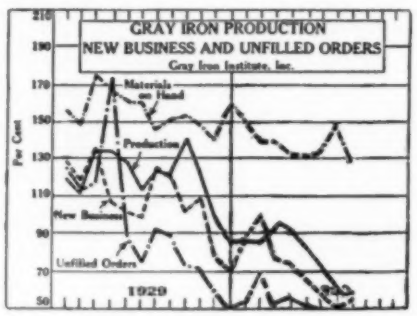
Stoney Foundry Engineering & Equipment Co., Cleveland, recently has built an office unit in connection with its factory. The address of the new office is 5321 St. Clair avenue.

Trade Trends in Tabloid

VARIOUS factors indicate that business is improving, although the movement in that direction is slow. Among the straws which reveal such trends may be included the up swing in car loadings, gains in or the maintenance of operating schedules in the steel industry and increased purchases of raw materials.

—T—T—

Foundry operations in the Pittsburgh district show a mild expansion over the past 30 days. Schedules still are seasonably light, except among steel mill equipment builders who continue to run nearly



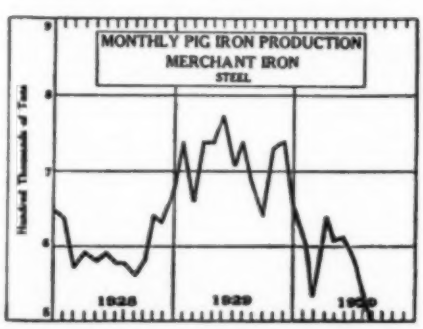
at capacity of machinery production. Roll output, however, is lagging, while production in most steel foundries varies from 60 per cent downward. Radiator and sanitary ware producers are busier than they were a month ago. Schedules of jobbing foundries vary widely, averaging from 2 to 5 days a week. Ingot mold production continues dull and below normal.

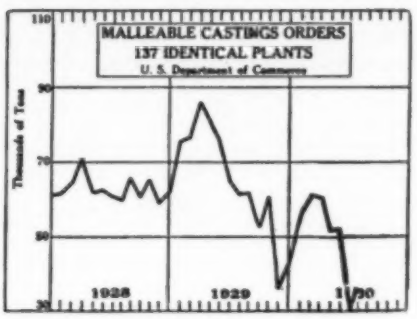
—T—T—

Production of automobiles reached a low point in August with a total of 223,046 compared with 262,363 cars in July. Little improvement is expected during the remainder of the year, while many makers start production of new models.

—T—T—

Stovemakers in the St. Louis district are feeling a seasonal increase in demand. Tractor manufacturers also report business improving, although other implement manufac-





turers have experienced little change. However, the outlook from western agricultural regions appears brighter than a month ago, and it is believed that fair business will be forthcoming from the rural sections.

—T—T—

Orders for gray iron castings gained 2 per cent in August, according to a report of the Gray Iron institute. New business in August was 56.3 per cent of normal compared with 54.2 per cent in July and unfilled orders increased from 32.7 to 48.4 per cent. However, production dropped slightly from 63.6 per cent in July to 62.8 per cent in August. The greatest activity was found in plants in Pennsylvania, Michigan, Ohio, Indiana and Illinois.

—T—T—

Steel foundry operations declined slightly in August, according to a report of the Steel Founders' Society

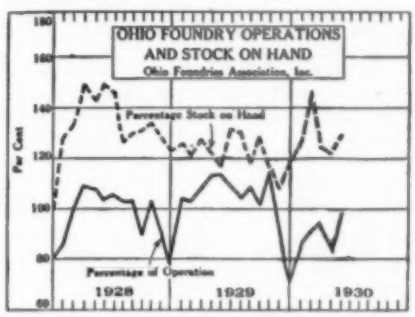
RAW MATERIAL PRICES
October 2, 1930

Iron	
No. 2 foundry, Valley	$17.50
No. 2 Southern, Birmingham	14.00
No. 2 foundry, Chicago	17.50
No. 2 foundry, Buffalo	18.50
Basic, Valley	17.00
Basic, Buffalo	18.00
Malleable, Chicago	17.50
Malleable, Buffalo	19.00
Coke	
Connellsville beehive coke	$3.50 to 4.85
Wise county beehive coke	4.25 to 5.00
Detroit by-product coke	8.50
Scrap	
Heavy melting steel, Valley	$15.00 to 15.50
Heavy melting steel, Pitts.	15.00 to 16.00
Heavy melting steel, Chicago	12.25 to 12.50
Stove plate, Buffalo	10.25 to 10.50
Stove plate, Chicago	9.50 to 10.00
No. 1 cast, New York	9.50 to 9.75
No. 1 cast, Chicago	12.00 to 12.50
No. 1 cast, Philadelphia	13.50
No. 1 cast, Pittsburgh	13.50 to 14.50
No. 1 cast, Birmingham	13.00 to 14.00
Car wheels, iron, Pittsburgh	15.00 to 15.50
Car wheels, iron, Chicago	13.50 to 14.00
Railroad malleable, Chicago	13.50 to 14.00
Agricultural mal., Chicago	12.25 to 12.75
Malleable, Buffalo	15.00 to 15.50
Nonferrous Metals	**Cents per pound**
Casting, copper, refinery	9.87½
Electro, copper, producers	10.12½ to 10.00
Straits, tin	28.00
Aluminum, No. 12, producers	22.00
Aluminum, No. 12, remelt	14.00 to 15.00
Lead, New York	5.35
Antimony, New York	7.37½
Nickel, electro	35.00
Zinc, East St. Louis, Ill.	4.20 to 4.25

of America. Twenty-nine out of 60 plants reporting were operating below 50 per cent. Twelve between 50 and 59 per cent, 4 between 60 and 69 per cent, 8 between 70 and 79 per cent, 5 between 80 and 99 per cent and 2 over 100 per cent. Out of 55 expressing an opinion on the business outlook, 3 stated that prospects are good, 38 reported fair and 14 indicated prospects poor.

—T—T—

Domestic freight car buying in September, according to preliminary estimates, dropped to 535 cars, the lowest monthly total for the year. Prospects for immediate improve-



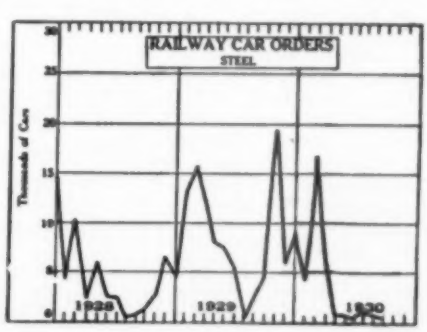
ment in this line are not good as only approximately 100 cars are on inquiry. Class 1 railroads on Sept. 8, had 404,450 surplus cars in good repair, a decrease of 13,867 cars compared with Aug. 31.

—T—T—

Operations in the Chicago district are improving slowly, the rate early in October being about 55 per cent against 40 to 50 per cent the first of September. Gains are reported among steel foundries, and domestic furnace and stove plants. Farm implement demand is quiet. Prospects are better for brass foundries, but bookings still are light.

—T—T—

Average New York prices on nonferrous metals during August, according to *Daily Metal Trade*, were as follows: Casting copper, 10.816c; electrolytic copper, 10.645c; Straits tin, 29.597c; lead, 5.50c; antimony, 7.78c; aluminum 98-99, 22.90c. Zinc averaged 4.266c, East St. Louis, Ill.



What the Foundries Are Doing

Reflecting the Activities of the Gray Iron, Malleable, Steel and Brass Shops

Mountain State Steel Foundries, Parkersburg, W. Va., are reported operating at approximately 75 per cent capacity.

Schuessler Foundry & Machine Co., Federal, Ill., recently was damaged by fire to the extent of $2500.

Jacobs Mfg. Co., Bridgeport, Ala., manufacturers of stoves, is running both day and night shifts in its plant.

William Gilbert, owner of the Ada Foundry, Ada, Okla., has a new foundry under construction at Rogers, Ark.

Vernon Foundry, Hollydale, Calif., has installed additional molding and coremaking equipment.

West Coast Foundry Co., Telegraph road and Atlantic boulevard, Los Angeles, has installed additional molding machine equipment.

O'Keefe & Merritt Co., 3700 Mines avenue, Los Angeles, stove manufacturers, has increased its capitalization to $500,000.

H. E. LaBour Foundry Co., Elkhart, Ind., plans to build a plant at 1537 Sterling avenue. Cost is estimated at $40,000.

Union Steel Castings Co., Pittsburgh, has been awarded the contract for 844,610 pounds of steel castings for the army engineer, Pittsburgh.

Department of correction, State building, Albany, N. Y. will receive bids for a foundry to be erected at Auburn, N. Y. The estimated cost is $40,000.

Saginaw Malleable Iron Co., Saginaw, Mich., subsidiary of the General Motors Corp., Detroit, has resumed operations after a 2-week shut-down.

U. S. navy yard foundry, Portsmouth, N. H., has been awarded 10,350 pounds of brass castings by the lighthouse service.

Master Brass Foundry, Los Angeles, has been dissolved and the equipment has been sold and removed from the plant.

Winona Machine & Foundry Co., Winona, Minn., plans to rebuild that portion of its plant recently damaged by fire.

American Furnace & Foundry Co., Milan, Mich., is reported to have resumed production after being closed approximately a month.

United States Pipe & Foundry Co., Burlington, N. J., is completing a 3-story laboratory for research in the production of cast iron pipes.

L. DeSanne, 1853 Thirty-eighth avenue, Oakland, Calif., will build a machine shop, pattern shop and foundry on Chapman street. The cost is estimated at $15,000.

Griffith Bros. Brass Foundry, 5908 South Main street, Los Angeles, has been taken over by Herbert Sutton and Henry Pein and now is being operated as the Acorn Brass Foundry.

William A. Huber, Belleville, Ill., is planning to operate a stove foundry in Mascoutah or Millstadt, Ill. The company expects to employ about twenty-five men.

Carroll Steel Foundry Co., Houghton, Mich., recently noted as planning a plant addition, has been reorganized with $250,000 capital. Several plant units will be built and new equipment will be purchased. The company will deal in steel, brass, aluminum and alloy steel castings. (Noted Oct. 1.)

Bay St. [illegible]
pee, Mass
Reginald [illegible] metals
and to operate a foundry and machine shop.

Torrington Casting Co., Torrington, Conn., whose plant recently was damaged by fire, has awarded a general contract for the rebuilding of the plant. The cost is estimated at $25,000. (Noted Sept. 1.)

Cranbrook Foundry & Machine Shop Ltd., Cranbrook, B. C., is having plans prepared for 2-story foundry and machine shop. The structure will be 40 x 60 feet and will cost approximately $12,000.

Leidecker Tool Co., Westview street, Marietta, O., recently became affiliated with the International Derrick & Equipment Co., Columbus, O. F. H. Leidecker is works manager of the Marietta plant of the company.

Barnett Foundry & Machine Co., 536 Lyons avenue, Irvington, N. J., has negotiated a contract for the manufacture and sale in the United States of pumps, feed regulators and other products of the Contra-Flo Co., London, Eng.

American Car & Foundry Co., 30 Church street, New York, is reported to be planning the reconstruction of its mine car plant at Bloomsburg, Pa., which recently was damaged by fire. Among the new units to be constructed will be a pattern shop.

Youngs Foundry, 234 Truslow street, Charleston, W. Va., which recently was destroyed by fire, is being rebuilt and is expected to be in operation by Oct. 1. The company manufactures gray iron castings. W. L. Young is manager of the company.

Crane Ltd., 1170 Beaver Hall square, Montreal, Que., has let a general contract to the United Engineers & Contractors Ltd., 1010 South Cathern street, west, for the construction of a 1-story, 330-foot addition to its foundry at 1280 St. Patrick street.

Shawinigan Stainless Steel & Alloys, Ltd., with headquarters at Montreal, Que., and foundry at Shawinigan Falls, Que., has begun the production of Nirosta metal castings. The company is a licensee of the Krupp Nirosta Co., Inc., New York.

Charles E. Chapman has become associated with George Phillips in the Supreme Aluminum Foundry, 1645 East Slauson avenue, Los Angeles. The company has expanded its facilities and has installed additional equipment. It will specialize in aluminum castings.

Steel Castings, Inc., Sand Springs, Okla., has been organized with $30,000 capital to manufacture steel castings by the converter method. S. F. Shoemaker is president and Larry Hinz, vice president and general manager. Both officers are connected with the Tulsa Stove & Foundry Co., Sand Springs, with which the new company will be affiliated. An addition will be built to the plant of the latter company to serve the new firm. Production is scheduled to start in 90 days.

[illegible]oga Stove and Foundry Co., Chattanooga, Tenn., has begun production. The first stove turned out by the company recently was presented to the mayor of Chattanooga with appropriate ceremonies. J. E. Abashire is president of the company. (Noted March 1.)

DeLaval Steam Turbine Co., Trenton, N. J., is reported operating five and one-half days a week with business good. Other companies in Trenton operating five days a week are the following: Trenton Malleable Iron Co., National Radiator Corp., Trenton Brass & Machine Co., and J. L. Mott Co., Inc.

Bureau of yards and docks, navy department, Washington, received bids Oct. 1, for improvements to the brass foundry at the navy yard. Improvements include concrete piling, structural steel work, steel windows and doors, steel roof deck, built-up roofing, sheet metal work, ventilating fan and stucco works.

California Malleable Casting Co., 4101 Whiteside avenue, Los Angeles, a subsidiary of the Consolidated Foundries, Bank of Italy building, San Francisco, has been closed and the equipment moved to the foundry of the Western Malleable Casting Co., 5801 South Boyle street, Los Angeles, another subsidiary of the Consolidated company.

Oliver Farm Equipment Co., Nichols and Shepard division, Battle Creek, Mich., is reported to have opened its foundry department at full production for the 1931 program. The move resulted upon a large order for farm machinery from the Russian government. The plant has 500 men at work and plans to recall an additional 500 late in December.

R. J. Schwab Furnace & Mfg. Co., 251 Reed street, Milwaukee, has moved its foundry, furnace and boiler manufacturing activities to Cedar Grove, Wis., where it will occupy the enlarged works of the Cedar Grove Stove Co. The company has disposed of its Milwaukee plant to the Wisconsin Gear & Engineering Co. and the Howard Brass & Copper Mfg. Co., both of Milwaukee.

The plants of the Oakland Foundry and its subsidiary, the Quality Stove & Range Co., both of Belleville, Ill., recently were damaged by fire to the extent of $500,000. Pattern shop, molding room, mounting room, machine shop, engine room, office and warehouse were practically destroyed. The companies were reported to be negotiating the acquisition of the local plant of the National Carbon Works, Maine and Ninety-fourth streets. Those plans later were abandoned and the company now proposes to build a new plant on East A street. The The unit will be 225 x 300 feet and will replace the plant which was destroyed. Henry Ehret is president and Hugo Ehret vice president and general manager of the Oakland company.